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THE

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EXPERIMENTAL FEEDING OF A PELLETED TROUT FOOD TO LARGE FINGERLING AND YEARLING BROOK, BROWN, AND RAINBOW TROUT, 1955-1956

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IN RECENT YEARS THE VALUE OF PELLETED TROUT FOOD has been under investigation by several States and the U. S. Fish and Wildlife Service (Brockway 1953, Willoughby 1953). The present paper compares the results of feeding a pelleted diet (Minnesota Pelleted Diet No. 1) and the standard meal-and-spleen diet to large fingerling and yearling brook, brown, and rainbow trout. The experimental feeding was conducted at the State Fisheries Station at Lanesboro, Minnesota, for seven 31-day feeding periods between August 24, 1955, and March 26, 1956.

The experiment was designed to determine whether the pellet diet could be substituted for the standard diet and save time and labor necessary for trout rearing. The regular diet had proved satisfactory during 4 years of use (1952-56), and it was necessary that any pellet diet should produce a similar high-quality fish. Another possible source of savings from use of a pellet diet was the elimination of refrigeration for food storage and of machinery for grinding and mixing every other day. Such savings, of course, could be had only if the pellet and regular diets were of equal nutritional value.

Design of Experiment

The trout in this pellet-feeding experiment were held in concrete raceways that were 40 feet in length, 5 feet in width, and had an average water depth of 16 inches. Each raceway was serviced with its own separate water supply, and the average flow per raceway during the experiment was approximately 50 gallons per minute.

Six raceways were used throughout the experiment: two each for brook, brown, and rainbow trout. At the start of the experiment, on August 24, 1955, exactly 25 pounds of fingerling trout were placed in each raceway. Fingerlings of the three species were of different sizes. There were 625 brook trout, 1,000 brown trout, and 720 rainbow trout in the 25-pound allotments (table 1). Fish in one raceway of each pair were fed the pelleted diet and in the other raceway were fed the standard diet.

Pounds of food fed and the number of mortalities occurring were recorded daily for each raceway.

Growth on the two diets was expressed as a percentage of the total weight at the beginning of each 31-day feeding period, determined by using the tables in the New York State Fish Hatchery Feeding Chart (Deuel, Haskell, and Tunison, 1942). The water temperatures were 48° F. during the experiment.

Composition of Diets

The regular diet fed in all Minnesota trout hatcheries from 1952 through 1956

TABLE 1.--Number and weight of three species fed pellet diet and regular diet

Species and diet	Start of experiment (August 24, 1955) Number of fish	Weight (pounds)	Number per pound	End of experiment (March 26, 1956) Number of fish	Weight (pounds)	Number per pound
Brook trout						
Regular diet-----	625	25	25.0	607	147	4.1
Pellet diet------	625	25	25.0	614	161	3.8
Brown trout						
Regular diet-----	1,000	25	40.0	1,000	184	5.4
Pellet diet------	1,000	25	40.0	996	196	5.1
Rainbow trout						
Regular diet-----	720	25	28.8	714	155	4.6
Pellet diet------	720	25	28.8	712	156	4.6

was a semimoist mixture of 55 percent meal and 45 percent freshly ground beef spleen. Composition of the meal components is shown in table 2. This diet was prepared 1 day in advance of feeding and mixed by tumbling to obtain food particles ranging from about 1/4 to 5/8 inch in diameter. The food was refrigerated at 32° F. until fed.

The pellet diet shown in table 2 was fed without fresh meat supplement. Pellets fed in this experiment were 1/8 inch in diameter and were prepared by a commercial feed firm to specifications.

The dry portion of the regular diet had an average protein level of 46.8 percent. The free-moisture content of the complete regular diet was 36.7 percent; the protein content of the complete regular diet was 30.4 percent. The cost of the dry-feed portion was $11.27 per 100 pounds, and the cost of the beef spleen was $6.99 per 100 pounds; both prices were f.o.b. Lanesboro Hatchery. The cost of the total ingredients of the mixed regular diet as fed was $9.34 per 100 pounds.

The analysis of the pellet diet (P-1) showed 42.1 percent protein and 5.2 percent free moisture. The cost of the pellet diet was $12.56 per 100 pounds f.o.b. Lanesboro Hatchery.

Method of Feeding

Food for trout in each raceway was weighed separately each day. Trout on the regular diet were fed twice a day, and trout on pellets were generally fed four times a day.

Trout on the regular diet were fed according to the Cortland feeding level as recommended by Deuel, Haskell, and Tunison (1942). Trout on the pellet diet were fed at 65 percent of this rate to provide a comparable feeding rate after allowance for differences in moisture content of the two foods. On an oven-dried basis, 100 pounds of the standard diet

TABLE 2.--Percentage composition of Minnesota standard trout diet and pellet diet No. 1 by weight

Ingredient	Standard diet[1/]	Pellet diet No. 1
Toasted Nutra soy flour----------	18	16
Cottonseed oil meal--	18	16
Spray-dried skimmilk	10	8
Wheat flour middlings	18	16
Whitefish meal-------	10	10
Primary dried yeast (Fleischman's 50-B)	10	10
Corn distiller's dried solubles-----	12	10
Iodized salt---------	4	2
Unextracted beef liver meal---------	--	12

[1/] Represents only the dry cereal portion, which comprises 55 percent of the complete feed. The remaining 45 percent is freshly ground beef spleen.

TABLE 3.--Growth rate of trout on pellet and regular diets for seven 31-day feeding periods

Feeding period	Percentage of body weight gained					
	Brook trout		Brown trout		Rainbow trout	
	Pellet	Regular	Pellet	Regular	Pellet	Regular
1	60.0	48.2	58.3	61.7	44.9	48.2
2	24.7	36.0	39.0	46.5	37.0	39.0
3	35.2	30.0	32.1	22.6	32.4	26.0
4	27.5	23.9	32.7	23.2	28.6	22.7
5	22.8	20.9	29.2	26.6	25.8	26.2
6	22.9	20.4	24.6	26.1	18.0	26.3
7	21.2	23.7	24.6	18.2	21.1	21.1
Aggregate percentage gain--	214.3	203.1	240.5	224.9	207.8	209.5

supplied 63.3 pounds of moisture-free food and 65 pounds of the pellet supplied 61.6 pounds of moisture-free food.

As previously stated, freshly ground beef spleen made up 45 percent of the weight of the regular diet, but no fresh meat was fed with the pellets.

Growth Rates

Weight gains by 31-day feeding periods for the 6 lots of trout on the 2 diets are shown in table 3. They are expressed as percentages of the initial aggregate weight for each period. It will be noted that there is no obvious, conspicuous difference in the gains shown by the three species of trout fed on the two diets. Conversion ratios were better for the pellet diet for all species and are shown in table 4.

To check the possibility that one diet might be superior to the other in several of the growth periods, the Chi-square common distribution test (Snedecor 1946) was used. This comparison was based on the observed weight gained during each 31-day growth period and was designed to determine whether the differences between the growth increment observed for each of the diets differed at each growth period from a common uniform growth increment by an amount greater than could normally be expected from chance or sampling variation.

This hypothesis was tested for each species. The Chi-square value for brook trout proved to be 1.388; for brown trout,

TABLE 4.--Conversion ratio, mean condition factor (C), and total mortality for trout fed pellet diet and regular diet for the entire feeding experiment

	Brook trout		Brown trout		Rainbow trout	
	Pellet	Regular	Pellet	Regular	Pellet	Regular
Mean conversion ratio[1/] ----	1.69	2.59	1.38	2.36	1.86	2.60
Mean dry weight conversion ratio[2/] ----------	1.60	1.64	1.31	1.49	1.76	1.64
Mean condition factor[3/] ----	41.25	40.21	44.04	43.88	44.21	38.22
Total mortality----------	11	14	4	0	8	6

[1/] Number of pounds of food fed to produce 1 pound of trout.

[2/] Number of pounds of food on a dry-weight basis, fed to produce 1 pound of trout.

[3/] C - calculated from the formula: $\frac{\text{weight in pounds} \times 100{,}000}{(\text{length in inches})^3}$.

TABLE 5.--Average estimated percent (EF)[1/] and calculated percent (CF)[2/] of body weight fed each day--by periods

31-day feeding periods	Brook trout				Brown trout				Rainbow trout			
	Pellets		Regular		Pellets		Regular		Pellets		Regular	
	EF	CF	EF	CF	EF	CF	EF	CF	EF	CF	EF	CF
1	1.50	2.46	4.2	3.30	2.5	2.32	3.9	3.08	2.36	2.53	3.6	3.03
2	2.34	1.65	3.6	2.64	1.68	1.66	2.6	2.30	2.26	1.52	2.5	2.27
3	2.01	1.83	3.1	2.97	1.43	1.29	2.2	2.22	2.50	2.19	2.0	1.49
4	1.30	1.70	2.0	2.48	1.04	1.19	1.6	2.15	1.30	1.48	2.0	2.25
5	.98	.848	1.5	1.15	1.30	.932	2.0	1.54	1.30	1.06	2.0	1.66
6	.98	.969	1.5	1.41	1.10	.954	1.7	1.49	1.30	1.17	2.0	1.83
7	.98	.929	1.5	1.34	1.10	1.00	1.7	1.63	----	.954	2.0	1.87
Mean--	1.48		2.18		1.33		2.05		1.56		2.06	

[1/] EF = Estimated percentage of body weight fed per day, based on weight of trout at beginning of each growth period.

[2/] CF = Calculated percentage of body weight fed per day. Formula from Deuel et al. (1942). $CF = \frac{2 \text{ (conversion ratio) (percentage gain) x } 100}{31 \text{ days } (200 + \text{percentage gain})}$.

2.332; and for rainbow trout, 2.292, with 6 degrees of freedom in all cases. It was concluded that the growth rate of trout fed the pellet diet could not be distinguished statistically from that of the trout fed the regular diet.

It is well known that trout can be fed beyond the point of most efficient conversion of food to flesh, and that such excessive feeding adds little to the growth rate over what could be had by feeding at the optimum level. Table 5 shows that during the fourth growing period lots of trout of all three species fed the regular diet were unintentionally fed a greater calculated percentage of their body weight (CF) than the estimated feeding rate (EF) warranted. This condition also occurred twice--in the first and fourth growing periods--with the pellet diet for both brook and rainbow trout.

Red Blood Cell Counts and Hemoglobin Level

Red-blood-cell counts and hemoglobin levels have been used as indicators of the suitability of various hatchery diets for salmon and trout (Tunison et al. 1939, 1943). By these measurements, anemia resulting from diets deficient in the essential nutrients may be diagnosed. Phillips (1940) and Phillips and Brockway (1947) studied nutritional anemia in hatchery trout. Phillips (1940) determined that mortality occurred among brook trout on a synthetic diet when the count of red blood cells per cubic millimeter dropped below 710,000; he fed the trout fresh beef liver as a therapeutic agent, and mortality ceased as the count of red blood cells increased again to 700,000. Tunison and coworkers (1943) determined that levels from 900,000 to 1,200,000 red blood cells per cubic millimeter were normal for hatchery-reared brook trout, and that anemia was indicated if counts were below 800,000 per cubic millimeter.

The mean hemoglobin level and red-blood-cell counts of samples of trout taken from each of the 6 raceways at the end of the seven 31-day feeding periods are listed in table 6. The differences between the means of pellet-fed lots and the lots fed the standard diet have been subjected to the common t test for significance (Snedecor 1946). The t values for mean hemoglobin levels indicate that at the 99-percent probability level there was no statistically significant difference for the brown trout fed the two diets; but there was a significant difference for brook

TABLE 6.--Hemoglobin levels and red blood cell counts for brook, brown, and rainbow trout on regular and pellet diets at the end of 28 weeks

Species and diet	Number of trout	Mean hemoglobin		Mean red blood cells			
		Grams per liter	"t" values and (d.f.) 1/	Red blood cells per cubic cm.	Range (x 1,000)	"t" values and (d.f.)	Standard deviation (x 1,000)
Brook trout							
Pellet diet	21	5.23	3.16 (40)	995,000	880 - 1,100	1.917 (37)	52.9
Regular diet	20	5.59		1,036,000	810 - 1,160		77.2
Brown trout							
Pellet diet	20	5.67	1.45 (39)	1,045,000	910 - 1,220	.965 (40)	76.5
Regular diet	22	5.78		1,023,100	910 - 1,220		71.0
Rainbow trout							
Pellet diet	24	5.85	13.12 (46)	1,002,000	910 - 1,150	1.410 (47)	55.6
Regular diet	25	6.72		1,031,000	920 - 1,210		82.2

1/ (d.f.) = Degrees of freedom.

trout and a highly significant difference for rainbow trout. Brook trout and rainbow trout that had been fed the pellet diet therefore had lower hemoglobin content in their blood than those on the regular diet, but there was no demonstrable difference for the brown trout on the two diets.

The t values for the mean red-blood-cell counts indicate no significant difference at the 95-percent probability level among fish of the three species when fed the pelleted diet and the standard diet. It seems, therefore, that the two diets were of about equal value for stimulation of red-blood-cell production.

Condition Factor

The length, by tenths of inches, and weight, by hundredths of pounds, were determined for 250 trout of each species on each diet at the end of the feeding experiment. The average condition factor for each species was determined and compared. The condition factors (C) for each diet are listed in table 4. The C factors for all three species were higher for trout fed the pellet diet than for trout fed the regular diet. This does not imply that the trout with a relatively high C factor have better stream survival but shows that the trout fed the pellet diet were at least as plump as those fed the regular diet.

Condition of Livers

Gross examination of the visceral mass was made of six trout of each species on both diets at the end of the experiment. The internal coloration of livers appeared similar for all species of trout fed the pellet diet and for brook and rainbow trout fed the regular diet.

The livers of the six brown trout on the pellet diet appeared slightly yellow, whereas the brown trout fed the regular diet had a healthy red color. Although red-blood-cell counts and hemoglobin levels apparently were normal for brown trout, there was evidence that the meatless pellet diet was producing a coloration not normal for this species. Alleviation of this problem may require periodic feeding of fresh beef spleen at weekly or biweekly intervals.

Mortality

As shown in table 4, mortality was low in all experimental groups. No statistical analysis of mortality was made.

Comparative Cost of Food

An accurate record was kept of the number of man-hours required to prepare the regular diet during the experiment, and it was found that 279 man-hours of

TABLE 7.--Comparison of costs of trout food and preparation between the regular diet and the experimental pellet diet (P-1)

Species and diet	Pounds of food fed to produce 1 pound of trout	Cost per 100 pounds for food and labor of preparation	Food and food preparation costs to produce 1 pound of trout	Percentage reduction in total cost to produce 1 pound of trout by pellet feeding
Brook trout				
Pellet diet	1.69	$12.56	$0.2123	23.6
Regular diet	2.59	10.74	.2779	
Brown trout				
Pellet diet	1.38	12.56	.1733	31.6
Regular diet	2.36	10.74	.2532	
Rainbow trout				
Pellet diet	1.86	12.56	.2336	16.3
Regular diet	2.60	10.74	.2790	
Mean cost reduction----------				23.8

labor were required to prepare 25,573 pounds of food. This was 1.09 man-hours per 100 pounds and included grinding the spleen and mixing the spleen and cereal. As labor was paid at the rate of $1.28 per man-hour, it cost $1.40 for labor to prepare 100 pounds of feed. This must be added to the food cost of $9.34 per 100 pounds; thus the total cost of preparing the regular diet was $10.74 per 100 pounds. Additional cost of refrigeration was not calculated. The cost of the pellet food was $12.56 per 100 pounds as delivered ready to feed.

As shown by conversion ratios of the diets as fed and by food and total costs for production of a pound of trout (table 7), feeding pellets resulted in a substantial reduction in cost per pound of trout produced for all three species. This cost reduction was 31.6 percent for brown trout, 23.6 percent for brook trout, and 16.3 percent for rainbow trout. Least reduction in costs for rainbow trout can be traced to the relatively poor conversion ratio (1:2.44) in the first and third growing periods. This was probably due to unintentional overfeeding with pellets.

Summary

A 7-month experimental feeding program for fingerling-to-yearling brown, brook, and rainbow trout with a special pellet diet and the regular Minnesota trout diet of meal and ground beef spleen showed that the pellet diet resulted in as good a growth rate as the standard diet. Costs incurred by feeding pellets were 31.6 percent less for brown trout, 23.6 percent less for brook trout, and 16.3 percent less for rainbow trout.

Conversion ratios on both feeding-weight and dry-weight bases were better for the pellets than for the standard diet. Red-blood-cell counts were about the same on both diets. Hemoglobin levels for trout fed the pellet diet were somewhat lower than those obtained with the standard diet for brook and rainbow trout but were well above the anemia level. Trout on the pellet diet had a higher condition factor than those on the standard diet.

Mortality was low on both diets.

Acknowledgments

This study could not have been so satisfactorily accomplished without the able assistance of personnel of the State Fish Hatchery at Lanesboro. Thanks are also extended to the Farmers and Merchants Milling Company of Glencoe, Minnesota, for assistance in preparation of the prescribed diet, and to Mr. Zane Scheftel for assistance in statistical work.

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LIGHT AS A FACTOR IN ACCELERATING THE SPAWNING OF BLUEBACK SALMON

Effects of light on the sexual maturation of adult blueback salmon have been studied at the Salmon-Cultural Laboratory (Entiat, Washington) of the Bureau of Sport Fisheries and Wildlife. Salmon in a light-tight pond with timer-controlled incandescent lamps have been exposed to various periods of light, while a similar group has been held in an open pond.

R. E. Burrows, who is in charge of work at this laboratory, has summarized the results of the 3-year study as follows:

1. Salmon exposed to almost continuous artificial light for more than a month during the 1955 experiment spawned a month later than the salmon in the open pond. Eggs of the delayed group were smaller than those of the control group, but the mortalities were comparable.

2. Salmon exposed to 9.25-hour periods of artificial light during the 1956 experiment spawned 19 days earlier than the control group. Female mortality was lower in the reduced-light group; egg and fingerling mortalities were significantly higher in that group than in the control.

3. Salmon exposed to 1-hour periods of artificial light for the 1957 study spawned 14 days earlier than the control salmon. Female mortality was higher and green-egg mortality significantly higher in the reduced-light group than in the control.

4. Light, not temperature, apparently was the prime factor in accelerating or retarding sexual maturation. The control salmon spawned at essentially the same time each year, though the temperature was 2.5° lower in 1955 than in 1956 and 1957. Salmon exposed to artificial light spawned at temperatures 5° lower in 1955 and 2° higher in 1956 and 1957, as compared to temperatures for the controls.

THE INORGANIC COMPOSITION OF BROWN TROUT BLOOD

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THE CHEMICAL COMPOSITION OF THE BLOOD of many species of higher animals is well known. This information has been invaluable in basic studies of animal physiology, in diagnosing pathological conditions, in establishing normal metabolism of the food of the animals, and in studying and culturing disease organisms afflicting higher animals. Studies of the chemical composition of fish blood in general are fragmentary and almost nonexistent for trout blood. This has been a handicap in studying trout physiology.

The most complete analyses of fish blood were reported by Field, Elvehjem, and Juday (1943), who determined a number of the inorganic elements in carp blood and a few of the more common organic components of trout blood. Other authors have reported specific blood components for a variety of species of fish: McCay (1930), phosphorus of catfish blood; Sarata (1938), copper of carp blood; Phillips et al. (1940), glucose of trout blood; Phillips et al. (1945), sodium chloride of trout blood; Saito (1954), some of the organic components of several species of marine fish.

The Cortland laboratory has received numerous requests for analyses of trout blood, as the information would be useful in formulating physiological saline solutions that are important in the study of trout disease. During the summer of 1956, the levels of nine minerals in brown trout blood were determined.

Method

Samples of blood were withdrawn from 2-year-old brown trout. Brown trout of this age were large enough to assure adequate blood samples but were too young to spawn during the year. Avoidance of spawning was considered important because it was desired to preclude abnormal blood composition caused by sexual activity. The trout averaged approximately 300 grams in weight. To assure standard conditions at the time of sampling for blood, the fish were fed at 4 p.m. the day before their experimental use and the samples of blood were taken the next day at 7 a.m. before the fish were fed. This practice made it possible to avoid the changes in blood chemistry that might have occurred if digestion and absorption of food had been at a peak when the blood was sampled. The blood was withdrawn from the fish by means of a cardiac puncture with a 2-cc syringe equipped with a 1.5-inch No. 26 hypodermic needle. For a complete series of analyses, relatively large samples of blood were required and it was necessary to pool the blood from individual fish until a total volume of 25 cubic centimeters of blood was obtained. The size of the samples of blood removed from individual fish ranged from 0.5 to 2.0 cubic centimeters. From 15 to 25 trout were required to obtain the necessary volume of blood. Individual trout were

THE INORGANIC COMPOSITION OF BROWN TROUT BLOOD AND A COMPARISON OF IT WITH THE BLOOD OF CARP AND HUMAN BEINGS

Constituent	Milligrams per 100 cubic centimeters							
	Brown trout			Carp[1]			Human beings[2]	
	Average	Range		Average	Range		Range	
				Blood serum				
Iron	0.25	0.25	- 0.25	0.025	0.016	- 0.033		
Chloride	424	419	- 438	401	347	- 446	450	- 500
Sodium	358	348	- 373	300	292	- 316	330	
Magnesium	2.3	2.1	- 2.5	3.3	2.5	- 3.9	1	- 3
Potassium	20.1	16.9	- 25.8	24.6	17.5	- 26.9	16	- 22
Calcium	12.5	11.6	- 13.6	11.5	9.5	- 14.8	9	- 11.5
Phosphorus, inorganic	9.3	8.6	- 9.9	8.69	6.79	- 12.10	3	- 4
Phosphorus, total	21.1	20.2	- 21.6	49	37.3	- 60.6		
Sulfate, inorganic	0.8	0.7	- 0.9	0.944	0.765	- 1.172	0.9	- 1.1
				Whole blood				
Iron	29.4	28	- 31				52	
Copper	0.28	0.26	- 0.30	0.10	0.08	- 0.109	0.5	- 0.25

[1] All values except copper taken from Field, Elvehjem, and Juday (1943); copper values from Sarata (1938).

[2] Values from Hawk and Bergeim (1937).

sampled only once during the experimental period. The pooled blood sample was allowed to clot, and the serum was recovered.

Some hemolysis occurred, as was evidenced by the pale pink color of the serum. The analytical results, however, indicated that only the value for serum iron was seriously influenced by hemolysis.

The serum was analyzed for iron, chloride, sodium, magnesium, potassium, calcium, phosphorus, and sulfate. For all analyses except sulfate, the minerals were determined by the methods described in the manual prepared for the Lumetron Photoelectric Colorimeter.[1] Sulfate was determined by the method of Letnoff and Reinhold (1936), which was adapted to the Lumetron colorimeter. In addition to the serum analyses, copper and iron were determined on whole brown trout blood. The blood was taken as described previously and was analyzed without separating the serum. Iron was determined by the Lumetron colorimetric method; copper, by McFarlane's method (1932), which was adapted to the Lumetron colorimeter. All analyses were made in duplicate on four separate pooled samples of blood.

During the experimental period, nearly 300 trout received a cardiac puncture and only 2 deaths occurred. The low mortality rate of the trout established the practicability of cardiac puncture for this type of study. The fear that a high mortality would result from taking samples of blood from valuable large trout is probably one reason for the paucity of values on the chemical composition of trout blood.

The results are summarized in the table. The values in the table represent the averages of the analyses of the four samples of pooled blood.

Discussion

The levels of minerals in the serum of trout blood (except total phosphorus and

[1] Manual for the Lumetron Photoelectric Colorimeter. Photovolt Corporation, New York 16, New York. Mimeographed.

iron) agree with those in carp blood serum (Field, Elvehjem, and Juday, 1943). The levels of most of the minerals in trout blood serum are similar to those in human blood serum (Hawk and Bergeim 1937), an observation reported for carp by Field, Elvehjem, and Juday (1943).

McCay (1930) reported that the level of inorganic phosphorus of catfish blood serum was about twice that of inorganic phosphorus in human blood. The results of these analyses of trout blood serum and of the analyses of carp blood serum (Field et al. 1943) support McCay's observation. The amount of total phosphorus in trout blood serum is approximately half that reported by McCay (1930) for catfish and by Field and his coworkers (1943) for carp. This difference may be due to a difference in species of fish. It is also possible that the nutritional status of the fish used in the three studies differed--and the difference in nutritional status at the time of sampling the blood caused the variation in total phosphorus reported by the different workers. The trout used in our studies were under standard nutritional conditions throughout the experimental period. The active absorption of food could have altered the phosphorus content of the blood. The range of the analytical values was much greater for total phosphorus of carp blood than for total phosphorus of trout blood (see table), supporting the contention that the carp were not under standard nutritional conditions when the blood was withdrawn from the fish. In general, the range of values for all of the investigated minerals of trout blood is narrow. The standardization of the nutritional status of the fish may have prevented the expected wide ranges of analytical results.

The high value for the iron in brown trout blood serum (see table) was doubtless caused by hemolysis that occurred during the preparation of the serum. Our values are approximately 10 times higher for brown trout blood serum than those that were reported by Field and his coworkers (1943) for carp serum. The value for iron in trout serum may not be valid.

The copper content of whole trout blood was higher than that of carp (Sarata 1938) but within the range of values reported for human blood (Hawk and Bergeim 1937). The iron content of whole trout blood was within the range reported for carp (Field, Elvehjem, and Juday, 1943) but considerably less than the value for human blood (Hawk and Bergeim 1937).

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STUDY OF TAG LOSS AND EFFECTS OF JAW TAGS ON BROOK TROUT

A study of tag loss and the effects of tags on mortality and growth of trout has been reported by James W. Mullan, aquatic biologist, Massachusetts Division of Fisheries and Game.

Between 1952 and 1955, approximately 80,000 catchable-size brook, brown, and rainbow trout released in Massachusetts streams had circular monel-metal tags attached to their mandibles. The procedure in the tagging work was essentially the same each year. The trout were immobilized temporarily with a solution of urethane (0.5 percent); then the tags (in various sizes for the different sizes of trout) were attached with standard factory tagging-pliers that had been altered to allow a slight overlap of the proximal ends of the tags.

For the study reported by Mr. Mullan from his headquarters at Westboro, 200 brook trout (average length, 8.07 inches) were jaw-tagged and segregated in a pool at the Sandwich State Fish Hatchery on March 30, 1953. To serve as the control group, 200 untagged brook trout (average length, 7.91 inches) were also placed in the pool.

On June 16, 1953, when the first check of these trout was made, there were 170 tagged trout (average length, 8.48 inches) and 182 untagged trout (average length, 8.66 inches). On January 7, 1954, when the final check was made, 126 tagged trout (average length, 10.95 inches) and 144 untagged trout (average length, 11.70 inches) were recovered from the pool. Three (1.5 percent) of the tags were lost during the experiment. The Chi-square values for the first 10 weeks and for the entire test period were 3.4 and 3.7, respectively. (These values were presumed not significant with relation to differential mortality between the lots of tagged and untagged fish.)

"Conditions relating to this experiment were such as to favor the expectation of a greater mortality among the tagged fish than would normally be experienced," writes Mr. Mullan. "For example, the tagging was done by inexperienced personnel, and -- through a misunderstanding -- the experimental fish did not receive the routine treatment for common hatchery parasites during the 9 months in question. However, field observations of liberated tagged trout in 1953 indicated a tag loss of about the same magnitude (about 1 percent) in the wild as in the hatchery. Of 2,291 trout creel-sampled 2 to 3 months after they had been tagged and stocked, 11 (0.4 percent) had lost their tags. Of 179 trout that were taken in population studies 4 to 6 months after they had been tagged and stocked, 3 (1.6 percent) had lost their tags."

RELATION OF A DRY PELLETED RATION TO NUTRITIONAL ANEMIA IN BROOK AND RAINBOW TROUT

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IN THE PAST, ADEQUATE TROUT NUTRITION required the feeding of raw fresh meat that contained a substance or a combination of substances essential for sustaining life and for growth. Lack of these substances resulted in anemia and death. McCay and Dilley (1927) found that diets having a sufficiency of vitamins A, C, D, E, and vitamin-B complex supported life and growth, but that anemia developed.

Tunison and coworkers (1939) also produced anemia, similar to that described by McCay and Dilley, on a synthetic diet. They found that the fish died when the red-blood-cell count was less than 700,000 per cubic millimeter. After this diet had been used for 4 weeks, various amounts of liver were added, with the result that the anemic group of fish fed 100 percent liver sustained no further excessive mortality. Subsequent tests of various liver extracts, autolyzed beef liver, raw liver, and fly maggots showed that the last two could cure and prevent this anemia. In feeding tests conducted for 1 year, the liver extracts increased the red-blood-cell count. However, the same effect was not obtained in later experiments.

It was thought that fly maggots and insect larvae might contain one of the pterins, and that its presence might prevent anemia in fish (Tunison et al. 1941). Simmons and Norris (1941) found that injection of xanthopterin into anemic fingerling salmon resulted in an increase of erythrocytes to an approximate maximum of 1,600,000 per cubic millimeter, and that there was a positive correlation between the amount of xanthopterin given and the increase in number of red blood cells. Later experiments by Tunison and coworkers (1942) at the Cortland Hatchery did not substantiate this claim. McLaren, Herman, and Elvehjem (1947), reporting on this problem, stated that no anemia developed when folic acid and biotin were added to an anemia-producing diet.

In 1953, the Michigan Department of Conservation began to investigate the possibility of using dry animal and vegetable meals for trout diets. During this investigation, erythrocyte counts were made on brook and rainbow trout blood to determine whether dry rations affected the level of red cells in the blood of the fish.

Procedure

Groups of rainbow trout and brook trout that numbered from 1,000 to 4,000 each were fed a control ration (100 percent raw beef liver) and a "dry" experimental ration. The fish in each group were 3 to 5 inches long and 9 months old when the dry diet was introduced. Fish receiving the control ration and those receiving the dry ration were treated identically. Prior to

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being fed the dry pelleted diet, all fish had been fed raw meat diets of various mixtures. The dry diet was fed in amounts equal to 1.5 to 1.9 percent of body weight per day; the control was fed in amounts equal to twice the dry ration. The amount of food per day was altered to correspond to seasonal changes in water temperature.

Erythrocyte or red-corpuscle counts were made on blood taken from the severed caudal peduncle of trout. Duplicate blood specimens were taken from each of four fish from each group. The blood was diluted with Hayme's solution in a pipette by filling the capillary to the 0.5 mark with blood and to the 101 mark with the diluting fluid. The diluted blood was then shaken in the pipette for 2 minutes. After being shaken, a small drop of blood was put on the counting chamber of a hemocytometer and the number of red blood cells was counted under the microscope.

Two groups of blood-count data are reported. One is from rainbow and brook trout fed the dry ration 4 days per week, raw beef liver 1 day per week (no food was given 2 days per week); the other is from rainbow and brook trout fed the dry ration for 12 months without raw-meat supplementation. Table 1 shows the composition of the dry diet; table 2, the proximate analysis on a moist and on a dry basis.

TABLE 1.--Percentage composition of a dry pelleted diet fed to rainbow and brook trout

Ingredients	Percentage
Red fish meal	38
Cottonseed meal	23
Wheat flour middlings	25
Torula yeast	5
Condensed fish solubles	3
Skim milk	5
Iodized salt	2

Results

Rainbow and brook trout that had red-blood-cell counts below 900,000 per cubic millimeter were approaching an anemic condition. As shown in table 3, the blood of both species of trout that were fed the dry pelleted diet with meat supplementation for nearly 2 years contained numbers of erythrocytes approximately equal to the numbers in the blood of liver-fed fish.

In order to determine the extent to which the raw-meat supplement affected the erythrocyte count of fish blood, groups of rainbow and brook trout which had been fed as previously described were placed on the dry pellet diet shown in table 1, without raw meat, in March 1954. One year later, erythrocyte counts from these fish were compared with counts from fish that had been fed a raw-beef-liver diet (table 4). The erythrocyte counts were closely comparable among fish of both groups at the beginning and the end of the 12-month period. Brook and rainbow

TABLE 2.--Proximate analysis of rations fed to rainbow and brook trout

Item	Constituents (percentage)							
	Moisture	Crude protein	Crude fat	Crude fiber	Carbohydrate[1]	Calcium	Phosphorus	Ash
Dry ration								
Moist basis[2]	8	39.6	5.0	4.7	25.2	3.2	2.1	13.3
Dry basis	0	42.8	5.5	5.1	27.2	3.5	2.3	14.3
Control[3]								
Moist basis[2]	70	20.2	3.1	.0	6.0	.007	.358	1.3
Dry basis	0	66.6	9.9	.0	19.9	.023	1.3	4.3

[1] Nitrogen-free extract.
[2] Ration in its natural state, before drying.
[3] Raw beef liver.

TABLE 3.--Number of red blood cells per cubic millimeter in blood of rainbow and brook trout fed different diets

Species and date	Weekly diet [1]: (Dry diet, 4 days; (raw beef liver, 1 day	Number of red blood cells per cubic centimeter in blood: Raw beef liver, 5 days
Rainbow trout		
May 20, 1953	1,123,000	1,120,000
July 24, 1953	1,130,000	1,200,000
November 6, 1953	1,020,000	1,260,000
April 30, 1954	1,370,000	1,170,000
February 4, 1955	1,298,000	1,153,000
Average	1,188,000	1,181,000
Brook trout		
May 18, 1953	1,269,000	---
July 12, 1953	1,130,000	---
October 14, 1953	1,111,000	---
February 4, 1955	1,386,000	---
February 15, 1955	1,074,000	1,201,000
April 26, 1955	1,170,000	1,116,000
Average	1,190,000	1,158,000

[1] Fish were not fed on 2 days of each week.

trout fed a dry diet had a slightly higher red-cell count after 12 months than did the liver-fed fish; the count for both the species fed the dry diet increased slightly during the experiment, whereas the count among liver-fed fish decreased slightly.

TABLE 4.--Number of red blood cells per cubic millimeter in blood of rainbow and brook trout fed dry or liver diets

Date	Number of red blood cells per cubic millimeter in blood: Rainbow trout: Dry diet	Rainbow trout: Liver diet	Brook trout: Dry diet	Brook trout: Liver diet
March 1954	1,140,000	1,344,000	1,269,000	1,215,000
March 1955	1,298,000	1,153,000	1,386,000	1,158,000

The small differences noted in erythrocyte counts are not considered important. However, it is clear that under the conditions of these experiments neither brook nor rainbow trout developed nutritional anemia when fed the pelleted dry diet, with or without a raw-meat supplement.

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THE MEXICAN TROUT IN CALIFORNIA AND NEW MEXICO

Because of the need to develop a trout suitable for stocking arid regions of the Southwest, Mexican trout (Salmo nelsoni) were brought from Durango to the U. S. Fish-Cultural Station at Truth or Consequences, New Mexico, in November 1956. Within a month, some of these trout had been placed in the care of the California Department of Fish and Game and the New Mexico Department of Game and Fish.

Of the trout held at the Federal station, William H. Kunesh, fish-culturist, Bureau of Sport Fisheries and Wildlife, reported:

"On December 1, 1956, the 78 trout averaged 0.846 ounce in weight and 4 inches in length. Each had had its right pectoral fin clipped.

"Eggs were taken from one female on December 12, but they were lost because the males produced no sperm. The water temperature was 58° F.

"On February 1, 1957, the 66 survivors averaged 0.97 ounce in weight and 4.5 inches in length, though their scales showed that they were well into the third year. Nine females gave eggs; the males were infertile. The fish did not feed so well as had been expected, and they fed most after dark. Water temperature was still 58° F.

"On August 1, 1957, the station had 45 healthy trout averaging 1.53 ounces in weight and 5 inches in length. The water temperature was 69° F., but feeding had improved and could be observed. Further, at this growth rate, as many as 2,000 fertile eggs could be expected from a healthy brood stock."

Of 194 received by a California hatchery, Seth Gordon, Director of the California Department of Fish and Game, wrote in October 1957:

"These trout have proved to be very wild ... under hatchery conditions. They have been difficult to feed and it was necessary to feed smaller particles of food than our regular production trout required. Total mortality to date amounts to 36 ... They have been treated for gill bacteria and fungus ... Growth has been fairly good, considering wildness and difficulty of feeding. They now average 15.3 per pound."

A New Mexico hatchery put 150 into a small tank and then, as they refused to eat, moved the survivors to an outside circular pond. In September 1957, Roy E. Barker, Chief of Fish Management, New Mexico Department of Game and Fish, wrote:

"There are about 32 of these fish, as near as we can tell. The pond has not been cleaned but has provided a natural habitat and is producing enough natural feed to keep these fish going. However, their gain in size has been very little ... We are still continuing to feed them but apparently they will not take any artificial food whether it be meat or dry food."

MULTIPLE SULFA THERAPY OF KIDNEY DISEASE AMONG BROOK TROUT

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KIDNEY DISEASE was identified in 1955 for the first time in Michigan among brook trout at the Oden and Marquette hatcheries. The disease had been reported previously only from hatcheries in the States bordering on the Atlantic and Pacific Oceans. Kidney disease at the Oden hatchery developed only in a group of brook trout hatched at the U. S. Fish and Wildlife Service's hatchery at Charlevoix. This hatchery received eggs from a hatchery in New England where kidney disease had been endemic for many years. As researchers have found some evidence suggesting that the disease might be transmitted by the egg, it was assumed that the New England hatchery was the source of infection at Oden. No such correlation could be found to account for the infection at Marquette. Brook trout there were hatched at the Thompson hatchery from eggs obtained from a hatchery in Pennsylvania, a source considered to be free of kidney disease. However, it is possible that the Pennsylvania hatchery had purchased eggs from an east-coast hatchery where kidney disease was present.

According to Snieszko and Griffin (1955), satisfactory control was obtained by treatment with sulfonamides; Gantrisin and sulfamerazine were recommended because they had the least retarding effect on growth of brook trout. Snieszko and Griffin (1955) reported that treatments with antibiotics (chloramphenicol, terramycin, and aureomycin) failed to control kidney disease. They also suggested that multiple therapy with several sulfonamides might prove to be more effective than therapy with only one sulfonamide. Opportunity to explore this suggestion came when 10 cement tanks at the Marquette hatchery became available for a limited time for use in experimentation, and 3 sulfa drugs were on hand.

Treatment Experiments

The 10 tanks were divided into 5 groups of 2 tanks each and labeled A, B, C, D, and E. Each tank was stocked with 200 brook trout, 27 months old and averaging 8 inches in length, chosen at random from the lot that had kidney disease. Treatments were instituted as follows:

A -- Control. No treatment.
B -- Sulfamerazine.
C -- Sulfamerazine and sulfaguanidine.
D -- Sulfamerazine and sulfadiazine.
E -- Sulfamerazine, sulfaguanidine, and sulfadiazine.

All drugs were fed at the rate of 12 grams per 100 pounds of fish per day, except to group E. Group E received 12 grams of sulfamerazine and 8 grams of each other drug per 100 pounds of fish per day. Drugs were fed as above for 4 consecutive days, then with two-thirds of this dose daily for the next 25 days, for a total of 29 days of treatment (March 12 to April 9, 1956). All the groups were observed for 22 days after the therapy.

The percentage mortality in all groups each week during the period of treatment did not demonstrate a particular trend except in group E, which received the three sulfas (table 1). Increase in mortality among the fish in this group may have been due to the large dose of drugs; posttreatment loss in this group was less than the loss during treatment. The posttreatment mortality in all groups except the control group was less than the mortality during treatment. In the control group, the mortality increased. The percentages given in table 1 were computed on the number of fish that remained at the beginning of each week.

TABLE 1.--Weekly mortalities

Week		Group A	B	C	D	E
During treatment--						
1	Number	8	7	2	8	4
	Percent	2.00	1.75	0.50	2.00	1.00
2	Number	4	3	7	4	9
	Percent	1.02	0.76	1.76	1.02	2.27
3	Number	6	4	4	5	13
	Percent	1.55	1.02	1.02	1.29	3.36
4	Number	5	5	9	3	9
	Percent	1.31	1.29	2.32	0.78	2.41
Total:						
	Number	23	19	22	20	35
	Percent	5.70	4.75	5.50	5.00	8.75
After treatment--						
5	Number	12	1	4	0	4
	Percent	3.18	0.26	1.06	0.00	1.09
6	Number	18	3	7	0	5
	Percent	4.93	0.79	1.87	0.00	1.38
7	Number	14	4	3	11	3
	Percent	4.03	1.06	0.82	2.89	0.84
Total:						
	Number	44	8	14	11	12
	Percent	11.67	2.10	3.70	2.89	3.29

Snieszko and Griffin (1955) reported that mortality from kidney disease began in April or May and reached a peak in June. The tanks were available for the present experiments only from March to May, which may account for the low mortality in the control group during March and the increase in mortality in this group in April.

As mortality in all groups was comparatively low, Chi-square tests were made to show whether or not the differences in mortality could be just the result of chance variations. The P values of these tests must be at a 95-percent or higher level to indicate significance. The higher mortality in group E during treatment was significant only when compared with group B and possibly group D, but all values in group E were considerably higher than in any other group (table 2). The P values of group A during the posttreatment period indicate that there was a significant difference in mortality compared to all other groups.

The Chi-square tests also show that there was no significant difference between the mortalities of all treated groups. This indicates that treatment with sulfamerazine alone was just as effective as treatment with various combinations of the three sulfas, and that all combinations of the sulfa drugs employed here were equally effective in controlling the disease. Furthermore, as some of the posttreatment mortality still persisted and kidney disease was present in all groups 22 days after treatment was terminated, it is evident that none of the treatments given was successful in completely eradicating kidney disease.

Summary

1. Kidney disease, known previously only from hatcheries bordering on the

Atlantic and Pacific Oceans, was identified in brook trout in Michigan.

2. Experiments on kidney disease in brook trout were made at the State Fish Hatchery, Marquette, Michigan.

3. The effect of sulfamerazine, alone and in combination with sulfaguanidine and sulfadiazine, on kidney disease was tested.

4. Kidney disease was controlled with all combinations of the three sulfa drugs. Sulfamerazine was just as effective alone as it was in combination with sulfaguanidine and sulfadiazine.

5. None of the treatments effected a complete cure.

Acknowledgments

The author wishes to express his sincere appreciation to Mr. Russell Robertson and the hatchery crew at Marquette for their fine cooperation in this study.

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TABLE 2.--Chi-square and P values of total mortalities

Group		Group B	C	D	E
During treatment--					
A	X^2	0.23	0.023	0.22	2.25
	P	35.4	11.5	34.7	85.7
B	X^2	-----	0.23	0.27	4.47
	P	-----	35.4	38.0	96.2
C	X^2	-----	------	0.10	2.72
	P	-----	------	24.3	90.1
D	X^2	-----	------	-----	3.83
	P	-----	------	-----	94.9
After treatment--					
A	X^2	25.7	15.8	17.0	17.5
	P	99+	99+	99+	99+
B	X^2	-----	1.14	0.49	0.59
	P	-----	71.2	51.1	54.4
C	X^2	-----	------	0.16	0.09
	P	-----	------	30.8	23.1
D	X^2	-----	------	-----	0.13
	P	-----	------	-----	27.9

The philosophy in modern Russia is very favorable toward scientific research. One is impressed daily by the amount of work that is being done in spite of the comparative poverty of the individuals of the nation. If the spirit of enthusiasm continues in Russia we may expect to find that nation our greatest rival in the field of scientific research and it is possible that Russia may invest more of its wealth and effort in research and thus even outstrip us as a nation. --C. M. McCay, "Fish and fish culture in modern Europe," PROGRESSIVE FISH-CULTURIST, January 1936.

Of four lots of fin-clipped fall chinook salmon released by a Washington hatchery in 1952, all had been reared in fresh water for 90 days but three lots had also been reared in salt water for 5, 25, and 60 days, respectively. Returnees in 1956 included 132 from the lot given no salt-water rearing, 213 from the lot reared 5 days in salt water, 76 from the lot reared 25 days in salt water, and 51 from the lot reared 60 days in salt water.

DISTRIBUTION OF BLUEGILL TREATED WITH TRICAINE METHANESULFONATE (M. S. 222)

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FISHERY WORKERS have been using anesthetics for several years to quiet fish while marking or tagging them, taking spawn, clipping fins, and doing other work on them. In fact, drugs are now accepted universally as a valuable aid in handling live fish. In more recent years, anesthetics have been used with varying degrees of success in transporting fish.

One of the best anesthetics in use is tricaine methanesulfonate (M. S. 222). It is instantly soluble in water, and--if it is used with caution--relatively few mortalities result when anesthetizing most species of fish. There are a few exceptions: fathead minnows, for instance, and some strains of rainbow trout seem very susceptible to M. S. 222 and usually never recover when anesthetized.

In an attempt to increase the number or pounds of bluegill which could be carried on distribution trips, field tests were conducted to determine the value of M. S. 222 under actual distribution conditions.

Materials and Methods

Because tests conducted in aquaria are often difficult to duplicate under actual operating or field conditions, it was decided to utilize the regular distribution units containing water and fish loaded exactly as they would be during normal hatchery operations. The bluegill were hauled in the units for 8 hours, during which brief stops were made periodically in order to simulate as closely as possible a normal distribution trip.

The fish trucks used had either 3 or 4 compartments, each of 60-gallon capacity. In all the tests, 40 gallons of water were used in each compartment. If more fish were added than the space available could accommodate, the water was allowed to spill.

Compressed oxygen was bubbled through the water at all times, as is ordinarily done in bluegill distribution.

It was hoped that the experiments would help to determine the optimum concentration of M. S. 222 which should be used in distribution, and the maximum number of pounds of fish which could be hauled by using this anesthetic. Previous laboratory experiments had shown that 0. 1 gram per gallon was probably the most promising concentration.[1/] With this information at hand, 3 concentrations were tested: 0. 05, 0. 10, and 0. 20 gram per gallon. In order to do this, the concentrations were held constant and the number of pounds of fish per compartment was varied.

After the most desirable concentration was established, it was used for the duration of the experiment. The number of pounds of fish per compartment was progressively raised in an effort to determine the maximum load.

One of the four compartments (or one of the three, depending on the type of unit in use) was the check or control. To

[1/] Webb, R. T. Tricaine methanesulfonate (M.S. 222) as an anesthetic for some common pond fishes. Unpublished thesis. Alabama Polytechnic Institute, Auburn. 1954.

observe aftereffects of the anesthesia, the fish were held in tanks or pools after the experiments were concluded.

Throughout this report, the term "normal load" is used. The normal load is the maximum number of fish which the hatchery superintendent would haul without the addition of the drug. This, of course, varies greatly with the weather, size of fish, individual preferences, and other conditions.

When these tests were started, it was decided to determine pH, oxygen, carbon dioxide, and temperature whenever the fish showed signs of distress. In most cases this was done, but the resulting data were so varied and inconclusive that they were not included in this report. For instance, the oxygen ranged from 2.0 to 3.5 parts per millimeter when fish were in distress, while the carbon dioxide ranged from 12 to 22 parts per millimeter.

Results

The first trial trip was made from the U. S. Fish-Cultural Station at Natchitoches, Louisiana. Each of the 4 compartments was loaded with 70 pounds of No. 5 bluegill (100 pounds per thousand). The normal load at this station was 50 pounds per compartment. At the end of 8 hours, all fish were in good condition (table 1). The bluegill in compartment 4, which contained 0.2 gram of M.S. 222 per gallon, were barely able to maintain an upright position and were rolled about by the bubbling oxygen. Although the fish recovered quickly when removed from the treated water, it seemed apparent that this concentration was too high for satisfactory results.

On the second trial, two trucks and distribution units were utilized simultaneously. These units were identical in construction. The fish were No. 2's (3 pounds per thousand), and the normal load was 40 pounds per compartment. (See tables 2 and 3.)

Owing to operational difficulties, these fish were transported for an additional 5 hours, or a total of 13 hours, en route.

In one truck, 60 pounds of fish per compartment were hauled; in the other truck, 70 pounds of fish per compartment, or nearly twice the normal load, were carried. In the more heavily loaded truck, this experiment could not have been more satisfactory (table 3). The fish in the concentration believed to be most suitable suffered no mortality, whereas 64 percent

TABLE 1.--Mortality of bluegill (No. 5's--100 pounds per 1,000) hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.0	70	0	0
2	.05	70	0	0
3	.10	70	0	0
4	.20	70	0	0

[1] Filled with 40 gallons of water.
[2] Normal load, 50 pounds.

TABLE 2.--Mortality of bluegill (No. 2's--3 pounds per 1,000) hauled 13 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.0	60	0	0
2	.05	60	6	10
3	.10	60	35	58
4	.20	60	30	50

[1] Filled with 40 gallons of water.
[2] Normal load, 40 pounds.

TABLE 3.--Mortality of bluegill (No. 2's--3 pounds per 1,000) hauled 13 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.20	70	5	7
2	.10	70	0	0
3	.05	70	43	61
4	.0	76	45	64

[1] Filled with 40 gallons of water.
[2] Normal load, 40 pounds.

of the fish in the check load were lost. The other load, however, was a different story (table 2). More than 50 percent of the fish in the compartment containing 0.1 gram of M.S. 222 per gallon died; and then, to add insult to injury, 100 percent of the bluegill in the check load survived.

On the next trial, only one truck was used. It was loaded with 100 pounds of No. 4 bluegill (30 pounds per thousand) per compartment. The results were encouraging (table 4). About 22 percent of the bluegill were lost in the compartment containing 0.2 gram of M.S. 222 per gallon, whereas none were lost in the compartment that contained 0.1 gram per gallon. Less than 1 pound (1 percent) of the bluegill died, however, in the control.

TABLE 4.--Mortality of bluegill (No. 4's--30 pounds per 1,000) hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.1	100	0	0
2	.0	100	Less than 1 pound	1%
3	.05	100	"	"
4	.20	100	22	22

[1] Filled with 40 gallons of water.
[2] Normal load, 50 pounds.

TABLE 5.--Mortality of bluegill hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load (pounds)	Mortality	
			Pounds	Percent
1	0.1	[2][3] 76	0	0
2	.1	[4] 70	0	0
3	.1	[4] 135	3	2
4	.1	[4] 135	5	4

[1] Filled with 40 gallons of water.
[2] 27 pounds of No. 4's and 49 pounds of No. 2's.
[3] No. 2's (3 pounds per 1,000).
[4] No. 4's (30 pounds per 1,000).

The 4 trials just described would indicate that 0.1 gram of M.S. 222 per gallon was the most promising concentration. It was evident that 0.2 gram per gallon appeared to affect the fish so much that they had difficulty in maintaining their equilibrium, and that they tended to pack at the surface when rolled up by the bubbling oxygen.

The next trip, and the final trial conducted in Louisiana, was a cleanup haul. Fish of different sizes had to be used (table 5), and no control or check was run. Again the results were very promising. In an attempt to reach the end point or maximum load, more than 3-1/3 pounds of bluegill per gallon of water were carried in 2 compartments which had losses of 2 and 4 percent. This was a tremendous load of bluegill, as any fish-culturist will agree. Compartment 2 was loaded with 70 pounds of No. 2's, or approximately twice the normal load; and losses were less than 1 percent--probably no more than would result in handling the fish on ordinary distribution trips.

The concluding 3 trials were conducted at the U. S. Fish-Cultural Station at Meridian, Mississippi. The normal load at this station was approximately the same as in the preceding tests, but the size of the available bluegill was different.

A glance at tables 6 and 7 will reveal that in these trips the maximum load was not approached, as there were no mortalities. The 227,000 bluegill weighing 5 ounces per thousand (table 6) made a very

TABLE 6.--Mortality of bluegill (5 ounces per 1,000, or approximately 3,440 per pound) hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.1	22	0	0
2	.0	22	0	0
3	.1	22	0	0

[1] Filled with 40 gallons of water.
[2] Normal load, approximately 50,000 per compartment or less.

TABLE 7.--Mortality of bluegill (No. 1's--900 to the pound) hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.0	37	0	0
2	.1	37	0	0
3	.1	37	0	0

[1] Filled with 40 gallons of water.
[2] Normal load, 25 pounds.

TABLE 8.--Mortality of bluegill (No. 2's--340 to the pound) hauled 8 hours in various concentrations of M.S. 222

Compartment[1]	M.S. 222 (grams to gallon)	Load[2] (pounds)	Mortality	
			Pounds	Percent
1	0.0	65	0	0
2	.1	65	3	5
3	.1	65	35	54
4	.1	65	10	15

[1] Filled with 40 gallons of water.
[2] Normal load, 40 pounds.

heavy load, as 150,000 was the normal load for this size of fish. Table 7 shows that the normal load for No. 1's was 25 pounds, whereas 111 pounds were successfully hauled. However, the undeniable fact remains that the fish in the control hauled as well as the drugged fish.

Table 8 is self-explanatory. Had this experiment been conducted to prove that anesthetics were harmful in distribution, the data resulting from this test would be exhibit A.

Conclusions

These tests indicate that 0.1 gram of M.S. 222 per gallon was the most promising concentration to use in distribution. Though some extremely heavy loads of bluegill were hauled, the most successful tests could not be duplicated and at times the control fish seemed to haul as well as or better than the drugged ones. It must be realized that these tests involved literally hundreds of thousands of fish, which, of course, makes duplication nearly impossible. There was a notable difference in the results when the localities were changed. This could have been due to a difference in the water, condition of the fish, method of handling, size of fish, or any number of variables. It indicates that, to achieve satisfactory results, the experiments should be conducted at one station with fish of the same size.

It has been suggested that an insufficiency of stored fat--used in the growth of sex products and to furnish energy--may be responsible for the disappearance of thousands of blueback salmon during the annual movement upstream in the Columbia River to the spawning grounds. Studies made by Canadian workers have indicated that, in order to spawn successfully, the blueback salmon should have retained about 25 percent of its dry weight as fat when it reaches the spawning grounds. The Washington State Department of Fisheries has reported that in 1956 blueback salmon caught below and just above Bonneville Dam contained 65 percent and 52 percent fat, respectively, and additional samples taken farther upstream indicated only gradual losses of fat except in areas where there were dams: although some fish taken in the spawning grounds had less than 20 percent fat, most of these either failed to spawn or were partly spent.

SAMPLING PROBLEMS IN CREEL CENSUS

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ABOUT FIFTY FISHERY BIOLOGISTS from ten States, the Canadian Wildlife Service, and the U. S. Fish and Wildlife Service attended a symposium on sampling problems in creel-census work at Iowa State College on March 19, 1956. Most of the ideas in this report have come from that meeting.

Annual expenditures for the creel-census work in this country run into the hundreds of thousands of dollars. The data that are collected by means of these censuses are very important in providing estimates of harvest and of type and quality of fishing, as annual inventories to detect changes in fish populations and in fishing success, and as measures of the effectiveness of various management procedures.

Many of the creel censuses are poorly planned, however, and the data collected are of much less value than they might have been if they had been collected in accordance with some controlled sampling scheme.

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The various types of creel censuses might be classified somewhat as follows:

Persons making the reports	Nature and extent of coverage			
		Confined to a sample		
	Complete	Indiscriminate	"Special" selection	Statistically selected
Fishermen------	A	C	D	E
Biologists or census clerks	B	F	G	H

Complete censuses, with reports coming from the fishermen (A), include those situations in which fishermen are required by law to report their catch. California has had considerable success with mandatory reports from all boat owners and captains taking fishing parties (Clark and Croker 1933; Croker 1937, 1940; Baxter and Young 1953). Some States have required reports on catch before issuing new licenses, but the data so collected may be subject to considerable error because the reports may be made so long after the catch that the memory is no longer accurate.

Complete censuses, with biologists or census clerks contacting the fishermen at the end of the fishing trip (B), are usually feasible only where the number of access points is limited and where every fisherman must check in and out (Fry 1949). In some test waters fishing licenses are exchanged for special permits on the way in and picked up again on the way out (Lord 1935, 1937, 1941, 1946; Cooper 1952, 1953; Heacox 1946; Holloway 1948; and

Thorpe 1938). As all the statistics are collected directly, there is no sampling problem; and we, therefore, need not discuss complete censuses further. Complete censuses provide opportunities for determining the effect of various sampling designs (Tait,[1/] Best and Boles 1956, Randle 1938). Analysis of variance of all the data as used by Tait has an advantage over the scheme used by Randle, and by Best and Boles, for in the latter method the results are subject to sampling error.

Creel censuses which depend on the fisherman to volunteer reports on his catch (C), usually on cards which he is asked to put in mailboxes or in special boxes located along the stream or lake, have generally been unsatisfactory (Clark 1934; Clark, Now, and Flinn, 1948; Curtis 1940; Hanson 1938; Cuerrier 1956; Solman 1951; Anonymous 1935; and others). Such creel censuses have the advantage, however, of being a relatively inexpensive source of data. The results are often of doubtful reliability because the fishermen volunteering information may be quite different from those choosing not to do so.

Sometimes creel data may be collected from a selected group of fishermen (D). Diaries or logbooks are distributed to anglers who are expected to keep records of their fishing (Allen 1951; Bishop 1955; Phenicie 1955; Cleary, 1953, 1956; Lagler and DeRoth 1953). Respondents are very likely to be persons who enjoy better than average fishing success, and their data can hardly be considered representative. Cleary (1956) pointed out, however, that the data can be obtained at little cost, and they may be quite comparable from year to year if many of the anglers report for several years.

A sample of fishermen may also be statistically selected, usually from license holders, for mail questionnaires (E). In California, postcards have been sent to a randomized sample of license holders annually since 1936 (Calhoun 1950, Clark 1953). In 1948 the results of the postcard survey were found to have little or no nonresponse bias when checked by a follow-up personal-interview survey. Colorado has also used a postseason personal-interview survey (Hunter 1949). In these surveys, memories may not be too accurate and the validity of the data is, therefore, difficult to evaluate. Furthermore, these postseason surveys rarely give information on individual waters but rather refer to the State-wide fishing picture.

By far the most common method of securing data on angling has been for biologists, conservation officers, or creel-census clerks to contact anglers while they are fishing or as they leave the lake or stream. Usually the angler is questioned to determine the length of time he has fished, his catch (which may also be examined at that time), and other information such as his fishing methods and home address. In some situations, as when there are few access areas, all fishermen may be contacted and a complete census (B) can be secured; but more often data must be collected from only a sample of fishermen. Often the contacts or interviews are made without any sampling plan (F) or, to use the terminology of the table, indiscriminately. There is often a tendency to collect data primarily at those locations where, and at times when, fishing is heaviest. Such a sample is probably not truly representative of fishing success. The enthusiastic biologist or census clerk, or one not overloaded with other work, may collect a much larger sample than he or someone else collected at another time and thereby introduce unassessable effects on the results.

In certain situations it may be desirable to contact fishermen only at a given access point or at a given time (G) and to use such data for comparison from year to year. As long as it is recognized that these data are representative only of the given site or time period and may not be representative of the general fishing in the lake or stream, such a method may have merit.

Benefits can usually be secured in a creel census by sampling according to

1/Tait, H. Some sampling problems in a Michigan creel census. Unpublished Ph.D. thesis. University of Michigan, Ann Arbor, Michigan. 131 pp., microfilms. 1953.

some statistical scheme. Only in this manner can measures of the reliability of the data be secured and certain biases be avoided. Statistically planned or controlled sampling need not, in many cases, be more expensive than the indiscriminate or unplanned sampling which is now in almost general use. In fact, it may be cheaper in some situations, as some of the sampling is unnecessarily large and inefficient. In some situations more adequate and reliable data could be obtained with smaller controlled samples (Tait[2]). Primarily, controlled sampling requires more planning. Most fishery biologists have little training or experience in planning such sampling programs. A good statistician, one who has experience in survey design even though he has none in creel census, may be able to provide much of the planning. Methods of survey design have developed rapidly in recent years (Cochran 1953, Snedecor 1956). Improvements in controlled sampling of angling data will come as we learn more about the variables which are met in each creel census (Embody 1954, 1955, 1956; Di Costanzo[3]).

Stratified sampling, in which random samples are taken from each segment or class of fishermen, is one statistical design that may increase the accuracy of the results or reduce the costs of collection (Kathrein 1953; Tait,[2] Tarzwell and Miller 1943; Di Costanzo;[3] Moore, Cope, and Beckwith, 1952; Mottley and Embody 1940; Eschmeyer 1942; Murphy 1955).

The first step in planning a creel census must be the selection of the type of information desired. Usually part or all of the following is sought:

1. Species composition of catch and size distributions of each species.
2. Number and type of fishermen (age, sex, geographical distribution, types of gear used, etc.).
3. Success of fishing (catch per hour, etc.).
4. Fishing pressure or effort (man-hours of fishing).
5. Harvest (usually product of items 3 and 4).
6. Characteristics of the fishing (seasonal, daily, hourly, and geographical distribution).

Knowledge of items 2 and 6 may be very helpful in setting up a stratified sampling system.

The times that the various counts or collections of data are to be made should then be scheduled. This first involves a determination of the season to be covered. If the fishing is year-round, the creel census must be year-round to be truly representative. Often, however, it is necessary to restrict the census to only a part of the season. It should then be recognized that the results apply only to that season, and that fishing in that season may not have the same relationship to fishing in the same season in another year as the fishing during the entire first year has to the fishing during the second. For example, the catch in April in a year that has an early spring may be 60 percent of the year's harvest, whereas the catch in an April with a late spring may be only 20 percent. Appropriate use of sampling can provide estimates for full seasons and therefore avoid the problem of truncating the season.

Fishing pressure and fishing success are not evenly distributed as to time of day, day of week, or week in season. These sources of variation can be controlled in simple cases by using a latin-square type of sample design. For example, if we have a body of water where the fishing day is 14 hours and the season is 7 weeks long and we can effectively use a time segment of 2 hours to make our observations, we can then set up a latin-square-type sample in which each day, each week, and each 2-hour period of the day will be equally represented over the season. The simplicity of this design is

[2] See footnote 1, page 74.

[3] Di Costanzo, C. J. Creel census techniques and harvest of fishes in Clear Lake, Iowa. Ph.D. thesis. Iowa State College, Ames, Iowa. 130 pp. 1956.

a consequence of the fact that we have exactly 7 time periods per day, 7 days per week, and 7 weeks in the season. Where this symmetry does not actually exist, it is sometimes possible to make certain adjustments which will achieve such symmetry. Otherwise, it may be necessary to use more complicated unbalanced schemes. As it is often obvious that weekend and holiday fishing differs from weekday fishing, many plans sample these separately; this is one of the most common adjustments to provide modified sampling intensity. Where sampling intensity is modified, plans and methods of analysis should be carefully worked out so that the best estimates can be obtained.

All portions of the body of water being dealt with should be included at each count or collection time. Where this is not possible, the area should be divided into sections which can be included in a single count and a sampling schedule established to ensure each section its proper representation in relation to time of day, day of week, and week in season.

In most creel-census plans, more thought has gone into the sampling design to estimate fishing pressure (such as the man-hours of fishing) than into the sampling problems of estimating the other desired statistics. The total hours of fishing can be estimated directly by counting all fishermen at scheduled times (set up according to the sampling scheme). If the time segment is 1 hour and the average number of fishermen fishing during that hour is determined, and if the hour is a randomly chosen one, we have an unbiased estimate of total fisherman-hours per hour for that day, week, or season from which the random hour was chosen. By multiplying this result by total hours in the day, week, or season, we have an unbiased estimate of fisherman-hours for the census period. The reliability of the estimate will, of course, increase as the number of such counts is increased.

Fishing pressure may also be estimated in two steps: (1) an estimate of the total number of fisherman-trips and (2) the average number of fisherman-hours per trip (Moyle and Franklin 1953).

The number of fisherman-trips can be determined by counting all fishermen (or boats) leaving or moving through all access points (by census or sample of either points or time or both). It would be very difficult, however, to determine number of fishing trips, either on an individual-person or boat basis, by direct observation of fishermen or boats on a body of water even by complete census unless it were possible to distinguish "new" ones, not previously noticed, from "old" ones. If a good estimate of total fishing trips is available, there is still the problem of obtaining a suitable estimate of the average fisherman-hours per trip. Where access points are limited, this may not be much of a problem so far as obtaining a good sample of trips is concerned. However, it will probably be necessary to depend on the fishermen's statements regarding the hours spent fishing during the trip.

Where fishing pressure is measured in parts, number of trips, and man-hours per trip, the general practice seems to be to take a rather small sample to determine man-hours per trip. It may be that this is less variable than number of trips, but studies should be made to determine the most efficient use of time between these two categories.

Occasionally, however, the number of fisherman-trips may be more easily estimated by some method other than that of counting the boats or fishermen on the lake. For example, automatic car counters on access roads (Shields 1956) may give an estimate of fisherman-trips if checks, according to a stratified sampling scheme, are made of the cars to determine the average number of fishermen per car (including cars containing no fishermen).

In estimating winter fishing pressure on Lake Mendota, Parker (1956) found that the distribution of fishermen on the lake each day could be represented by a flat curve in which the peak was from 11 a. m. to 2 p. m. A count was therefore made each day between these hours, and the fishing pressure was estimated on the basis of the area under a curve with a flat

peak at that count. If the hourly variation in the distribution of the fishermen is significantly less than the day-to-day variation in the numbers of fishermen, this scheme probably is quite efficient. However, there is great danger of bias if the pattern should shift. If at the same time the fishermen were being counted they were also contacted to determine their catch per effort, larger samples could be secured than by contacts at various hours; but these larger samples would be biased if there were much hourly variation in fishing success.

In most creel censuses, little planning has gone into the sampling problems in estimating fishing success (e.g., catch per man-hour). Even where stratified sampling schemes are used in estimating fishing pressure, the catch per unit of effort is usually estimated through a more or less indiscriminate sampling, whenever time permits. As fishing success varies with the time of day and season, controlled sampling schemes are also important in estimating catch per effort.

In estimating fishing success, one question that has received some attention is that of whether catch-per-hour estimates should be secured from fishermen while they are in the process of fishing, or whether such data should be collected only at the end of a fishing trip. The principal difficulty in using data from completed fishing trips is that such data are likely to be collected only at the major access points and only at times when many fishermen are coming in from their fishing. Such data may not be truly representative of fishing success. Furthermore, if data are collected according to certain sampling schemes, some hours will have very few fishermen completing trips, as compared to the number of fishermen that could be contacted while they were fishing.

In Michigan (Schafer 1956) significant differences were found between fishing success determined from incomplete and from completed fishing trips, and only the completed-trip data were included in their censuses. At Clear Lake, Iowa, the differences were significant if all the data were included but were insignificant if data from incompleted trips were compared with data from the same trips at their completion (Di Costanza 1955). It is believed that biases in sampling the completed-trip data explained the differences in the first comparison, and that data from incomplete trips were more reliable. In Maryland (Elser 1952) fishermen contacted while they were fishing were given cards on which to report the completed trip.

Usually, in estimating catch per hour, the biologist is dependent on the angler's knowledge of the time he has been fishing. Many anglers are rather proud of being oblivious of time while fishing. In one study in Minnesota (Johnson 1956), the fishermen's estimates of the time spent in each fishing trip were compared with the observed times at which the boats left and returned to the docks. Though the individual estimates varied greatly, the average estimate of about 1,700 trips was very close to the actual time spent on the lake.

Another problem is that most anglers will report the entire time as being spent in fishing, whereas part of the time may have been spent on shore eating lunch or doing other things. During such times the angler would not have been counted in estimating the fishing pressure, and thus there would be a bias in multiplying the estimated fishing pressure by the estimated catch-per-hour to get an estimate of the harvest.

At times, particularly when contacts are made during fishing, the biologist may not see the fish but will depend on the angler's estimate of the number caught and on his identification of the species. We know of no measure of these errors.

In some studies, individual data on catch per unit of effort have been averaged and even tested for significant differences. It should be pointed out that these are ratios, and that the mean is not an unbiased estimate of the catch per unit of effort of the entire fishing unless there is no correlation between catch per unit of effort and time spent in fishing. Usually a better estimate is secured by dividing the total catch by the total fishing time.

Estimates of the harvest, i.e., the total catch of fish, can seldom be made in

a direct fashion, but rather are derived from the estimated fishing pressure multiplied by the estimated success of fishing. However, in the Yellowstone Lake creel census (Moore, Cope, and Beckwith, 1952) the harvest from Fishing Bridge and some shore areas is made directly by counting, from a vantage point, all fish as they are caught. Direct estimates of harvest may also be made by counting the fish brought to access points (if the access points are limited enough for a given body of water) at certain periods of time, selected in accordance with some controlled sampling scheme to give representative samples. A direct estimate of the harvest and an estimate of fishing pressure from counts of fishermen might give a more valid estimate of catch per hour than that derived by interviews of fishermen, as it would not depend on the individual fishermen's estimates of length of time spent fishing.

Wherever possible, independent estimates and supporting or testing data should be secured. For example, if the harvest and fishing pressure can be estimated directly, interviews of fishermen to get catch-per-hour data may be useful. Boat-livery records may make it possible to check fisherman counts on a lake or stream (Di Costanzo 1955; Moore, Cope, and Beckwith, 1952; Ruhr 1956). Tagged fish may give an independent estimate of total harvest which can be compared with a creel-census estimate of total harvest.

Statistical treatment of creel-census data to get the best estimate of the various parameters depends on the sampling scheme. Analysis of variance has been used (Embody 1954, Murphy 1955, Mottley and Embody 1940, Mottley 1949).

It is clear that the sampling programs must be "tailor-made," or designed for each specific situation, if they are to be most efficient. In many waters, different segments of the fishery will have to be sampled by different methods. A good example of this is the Yellowstone Lake creel census (Moore, Cope, and Beckwith, 1952). As more is learned about the characteristics of a particular fishery, the creel-census methods can be improved. As with all research, a great deal is lost when it becomes just a routine procedure.

Summary

A review of creel-census methods now in use emphasizes the need for more attention to problems in sampling. Only when sampling is done according to some statistical scheme can reliability of the data be measured and certain biases be avoided. The sampling scheme should take into account hourly, daily, and seasonal differences in fishing pressure and success and the geographical distribution of the fishermen. Fishing success of fishermen contacted during fishing may be the same as, or may differ from, that of fishermen contacted at the end of their trip. Sometimes fishing pressure and/or success can be estimated in more than one way, and such parallel estimates may be valuable evidence as to the validity of estimates.

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Riboflavin is an essential growth factor for rainbow trout. At the Eastern Fish Nutrition Laboratory (Cortland, New York) of the Bureau of Sport Fisheries and Wildlife, rainbow trout fed for long periods a riboflavin-deficient diet have developed the eye lesion described in the literature as typical of this deficiency in salmon and lake trout.

REPORT ON OPERATION OF THE LAKE CHICOT FISHWAY

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LAKE CHICOT comprises approximately 2,000 surface acres impounded in the winter of 1942-43.

During the early part of 1954, a fishway was constructed on the Lake Chicot Spillway by the Louisiana Recreation and Park Commission. This fishway was constructed to aid the large numbers of fish which congregate below the spillway each spring to enter the lake proper. The Louisiana Recreation and Park Commission, upon completion of this fishway, requested the Louisiana Wild Life and Fisheries Commission to make a study of the fish using this structure. The purpose of this study was to determine whether fish in this locale (Louisiana) would utilize such a structure and, if so, which species, and how many. This study was begun on May 21, 1954.

Procedure

The Lake Chicot Fishway is constructed on a slope of 1 to 10. The inside of the structure consists of a series of alternate cement baffles affixed to the sides. The purpose of these baffles is to provide relatively calm areas that fish can use as resting spots. The over-all dimensions are 100 feet in length and 4 feet in width. At the upper or lake end, a gate was constructed to control the flow of water passing through the fishway. The upper opening to the fishway was approximately 6 inches lower than the spillway level. This lower level allowed water to flow through the fishway even though the level of the lake had dropped below the spillway level.

(Photograph by D. W. Geagan)

For the purpose of recording the fish using the fishway, a wooden trap covered with 1-inch chicken wire was placed near the upper end. This mesh was reduced to 0.5-inch hardware cloth after the 1954 operation, as the 1-inch chicken wire permitted too many of the smaller fish to pass unrecorded into the lake. All fish using the fishway entered this trap and remained captive until the trap was raised. When the trap was raised, the entrapped fish were recorded and released.

During the operating seasons, the trap was raised 3 times daily. At this time all fish caught in the trap were identified and counted. All the trash and commercial fish were either destroyed or given away. Game species of available size--

which included largemouth bass, Micropterus salmoides (Lacépède), over 10 inches; white crappie, Pomoxis annularis (Rafinesque), over 7 inches; bluegill, Lepomis macrochirus (Rafinesque), over 5 inches; redear sunfish, L. microlophus (Gunther), over 5 inches; and the warmouth, Chaenobryttus coronarius (Bartram), over 5 inches--were weighed, measured, and tagged with a numbered monel strap tag attached to the operculum. Game fish under available size were merely counted. All game fish were released into the lake after being recorded.

TABLE 1.--Species recorded as using the fishway during the observation period for 1954

Species	Number of fish	Percentage of total	Size groups (inches)
Bluegill-------	164	61.2	3.00 - 9.00
Redear sunfish-	4	1.5	3.50 - 5.75
Black bass-----	24	9.0	7.00 - 12.00
Black crappie--	6	2.3	5.00 - 7.00
Channel catfish	1	.4	13.50
Buffalo--------	33	12.3	3.50 - 10.00
Carp-----------	2	.7	11.00 - 11.50
Gar------------	2	.7	18.25 - 20.00
Shad-----------	32	11.9	4.00 - 6.00
Totals------	268	99.9	

The operating periods covered by this study include from May 21, through June 11, 1954; March 14, through July 11, 1955; and from March 15, through June 8, 1956.

Results

As the operating period for 1954 was not begun until after the high water from the spring rains had subsided, and mesh of the enclosing wire on the trap at that time was considered too large, the 1954 operating season cannot be compared with those of 1955 and 1956. However, for the purpose of illustrating the operation for the complete period during which this fishway has been constructed, table 1 has been included.

It is felt that the seasons of 1955 and 1956 presented a much more accurate picture of the utilization of the fishway--partly because of the much smaller mesh trap, and also because the way was opened as soon as water began going over the spillway as a result of the spring rains. During this period a daily check was made to see whether fish had begun coming up the fishway. As soon as fish began to appear in the trap, the regular study was begun. This study was continued until fish ceased to use the way in the summer. This closing time usually corresponded to the beginning of the summer dry period.

In comparing the operation of the fishway during these two seasons, it is noted that the number of fish using the fishway was 2.3 times greater in the 1955 season than in that of 1956. It is difficult to account for this larger number for 1955. Though the 1955 season was longer, the fishway was operated only 1.4 times more days--and this longer period was during the summer, when few fish were using the way. It was thought at first that a greater number of days with water flowing over the spillway might have occurred in 1955 than in 1956.

Table 2 was compiled to provide a comparison of these two seasons with regard to the number of days when the water was at various levels with respect to the spillway level.

It is interesting to note that, though the number of days of operation was considerably larger for the 1955 season, the percentages of the number of days at the three levels of water varied very little. The three water levels--over the spillway level, spillway level, and below spillway level--were established for the purpose of affording a comparison of water flow in the vicinity of the stream below the spillway. As the stream below the spillway depends a great deal on the flow of water over the spillway, the more water there is flowing over the spillway, the greater the rheotropic effect should be--also, the more water there is available to provide space for the movement of fish. Actually, the spillway-level category and

TABLE 2.--Comparison of water levels during 1955 and 1956 seasons

Water levels	1955		1956	
	Number of days	Percentage of total	Number of days	Percentage of total
Water flowing over spillway--	70	58.33	45	52.33
Water spillway level---------	8	6.67	7	8.14
Water below spillway level---	42	35.00	34	39.53
Totals----------	120	100.00	86	100.00

the below-spillway-level category could be combined, for neither level provides water over the spillway for the downstream area.

For the 1955 and 1956 seasons, almost the same fish species utilized the fishway. The only difference was that the black bullhead, Ameiurus melas (Rafinesque), and freshwater drum, Aplodinotus grunniens (Rafinesque), utilized the way only in 1955, and the yellow catfish, Pilodictis olivaris (Rafinesque), and warmouth utilized it in 1956. The remaining species of fish used the fishway during both the 1955 and the 1956 seasons. Table 3 shows the breakdown according to species of fish using the fishway during the two seasons.

The same species generally used the fishway during the two seasons, but their individual total numbers were different. However, the percentages of the total were surprisingly similar. Also of significance is the fact that the bluegill constituted 63.94 percent of the total number using the way in 1955 and 64.77 percent in 1956. The majority of these were fish less than 5 inches in length (96.75 percent for 1955 and 95.58 percent for 1956). Because in Louisiana waters the bluegill has proved its ability to propagate very rapidly, it is doubtful that these small bream were needed or that they added significantly to lakes having established bluegill populations.

The second-largest group was formed by gizzard shad, Dorosoma cepedianum (LeSueur), and threadfin shad, Signalosa petenensis (Gunther), which constituted 24.73 percent in 1955 and 25.04 percent

TABLE 3.--Fish using the fishway during 1955 and 1956 seasons

Species	1955		1956	
	Number using fishway	Percentage of total number	Number using fishway	Percentage of total number
Largemouth bass--------	540	4.11	271	4.82
White crappie----------	92	.70	16	.28
Bluegill---------------	8,399	63.94	3,642	64.77
Redear sunfish---------	423	3.22	184	3.27
Longear sunfish--------	52	.40	51	.91
Warmouth---------------	-------	------	4	.07
Unidentified sunfish---	107	.81	-----	------
Blue catfish-----------	128	.97	13	.23
Yellow catfish---------	-------	------	13	.23
Buffalo----------------	31	.24	20	.36
Freshwater drum--------	48	.37	-----	------
Carp-------------------	62	.47	1	.02
Shad-------------------	3,249	24.73	1,408	25.04
Black bullhead---------	5	.04	-----	------
Totals----------	13,136	100.00	5,623	100.00

TABLE 4.--Species collected in two population samples[1/]

Species	Sample No. 1[2/]		Sample No. 2[2/]	
	Pounds per acre	Percentage	Pounds per acre	Percentage
Nonpredaceous fish-----	167.2	81.80	53.7	61.58
Bluegill----------	43.6	21.33	22.4	25.69
Redear sunfish------	5.5	2.69	3.3	3.78
Longear sunfish-----	.4	.20	----	-----
Warmouth sunfish----	6.8	3.33	6.2	7.11
Stumpknocker sunfish	.4	.20	(3/)	-----
Gizzard shad--------	106.5	52.10	18.5	21.22
Suckers (chub)------	.7	.34	----	-----
Yellow bullhead-----	2.3	1.13	----	-----
Black bullhead------	-----	-----	1.1	1.26
Eel----------	-----	-----	.2	.23
Other fishes--------	1.0	.49	2.0	2.29
Predaceous fish--------	37.2	18.20	33.5	38.42
Largemouth bass-----	16.9	8.27	15.4	17.66
White crappie-------	5.1	2.50	.8	.92
Black crappie-------	7.8	3.82	15.5	17.78
Spotted gar---------	3.2	1.57	1.3	1.49
Blue catfish--------	-----	------	.5	.57
Bowfin----------	4.2	2.05	----	-----
Totals----------	204.4	100.00	87.2	100.00

[1/] These rotenone population samples were collected by Victor Lambou, September 1954.
[2/] One acre in size. [3/] Less than 0.05 pound.

in 1956. The two species of shad were counted together because the threadfin shad were of considerable size and the operator of the fishway was not experienced enough to furnish confidence in his ability to distinguish between these two species. Shad, particularly gizzard shad, have shown themselves to be undesirable in too great numbers in Louisiana waters. Both species have a tendency to overpopulate because of their great prolificacy. Therefore, it is not believed that the lake's fish population balance would be improved by the addition of these fish. In fact, population samples collected with rotenone indicate that Chicot Lake already has a large shad population. See table 4.

In evaluating a structure such as the Chicot fishway, the game species using the fishway should be compared with the rough or non-game species. Such a comparison is especially important because the structure was built to provide access for game fish, in particular, to the lake. Table 5 provides this comparison.

Table 6 lists the sizes and types of game fish using the fishway.

In 1955, of the 9,454 game fish shown in table 6, a total of 8,399 (88.4 percent)

TABLE 5.--Comparison of game fish and rough fish using the fishway during 1955 and 1956 seasons

Species	1955		1956	
	Number using fishway	Percentage of total number	Number using fishway	Percentage of total number
Game---	9,454	71.97	4,168	74.12
Rough--	3,682	28.03	1,455	25.88
Totals	13,136	100.00	5,623	100.00

TABLE 6.--Available-size game fish grouped according to species using fishway in 1955 and 1956

1955	Largemouth bass	White crappie	Bluegill	Redear sunfish	Warmouth	Total
Total number using fishway	540	92	8,399	423	------	9,454
Number of fish, available size	108	19	273	170	------	570
Percentage of total number of each species, available size	20.00	20.65	3.25	40.18	------	-----
Percentage of total number of fish using fishway, available size	0.82	0.14	2.08	1.29	------	4.33
1956						
Total number using fishway	271	-----	3,642	184	4	4,101
Number of fish, available size	57	-----	161	73	4	295
Percentage of total number of each species, available size	21.03	-----	4.42	39.67	100.00	-----
Percentage of total number of fish using fishway, available size	1.01	-----	2.86	1.30	0.07	5.24

were bluegill. Of these 8,399 bluegill, only 3.25 percent were of available size (5 inches or over). The percentages of available size of the remaining game species were somewhat larger, but the total numbers of the individual species were not large enough to be significant. The 570 available-size game fish for 1955 constituted only 6.03 percent of the total of 9,454 game fish, and the 295 available-size game fish for 1956 were only 7.19 percent of the total of 4,101 game fish.

In 1955, the largemouth bass using the way numbered 540. This would be only 0.27 bass per acre in a lake the size of Chicot. In 1956, the number of bass was only 271, or 0.13 fish per acre. The bass has been used here as an example because this is one of the most sought-after game fish in the lake. It is extremely doubtful that the entrance of these fish into the lake was felt by the local sport fishermen.

During the periods of operation in 1955 and 1956, a monel strap tag was affixed to the operculum of 760 of the 865 available-size game fish using the way. This was done to obtain some idea as to the movement of these fish after they had entered the lake and some information as to how many of these available-size game fish were harvested. The tag returns were made on a voluntary basis; therefore an error in evaluating the total number of fish recovered could have occurred. However, there are only two boat landings on Lake Chicot and, in an effort to minimize this error, the park employees operating these landings were educated in obtaining the tag-return information.

Of the 760 tagged fish, a return of only 22 fish (2.9 percent) was made (table 7). No sick or dead tagged fish were ever observed in the lake. Even considering the possible error in the voluntary tag returns, this return of 2.9 percent was low.

This tagging operation also showed that some of the fish using the way were washed back over the spillway. Whether this return movement was voluntary is not known, but 1.8 percent of the tagged fish were caught a second time in the trap after having returned up the fishway. If this movement to below the spillway was involuntary, in that these fish were washed over the spillway, then the number should be even greater among the smaller untagged fish.

Summary

1. The Lake Chicot Fishway was the first of its kind constructed in Louisiana for the purpose of stocking an impoundment of this type.

2. Certain species of fish gathering below a spillway structure such as is found on Lake Chicot will utilize a fishway of this type to gain entrance into the lake proper.

3. This movement is noted during the spring rains and for a short time thereafter as they cause a flow of water over the spillway.

4. Approximately one-fourth of the fish utilizing this structure are of species that are undesirable in a lake used primarily for sport fishing.

TABLE 7.--Tagged fish

Species	1955 Number of fish using fishway	1955 Number of fish tagged	1956 Number of fish using fishway	1956 Number of fish tagged	Total number of tags returned 1955 and 1956
Largemouth bass---	540	108	271	10	5
White crappie-----	92	19	-----	---	--
Bluegill----------	8,399	273	3,642	124	3
Redear sunfish----	423	170	184	54	14
Warmouth----------	-----	---	4	2	--
Totals-------	9,454	570	4,101	190	22

5. Of the total number of fish using the way, approximately three-fourths were game fish; but only 6.03 percent of these were of available size for 1955 and only 7.19 percent for 1956.

6. The bluegill constituted 63.94 percent of the fish using the way in 1955 and 64.77 percent in 1956. It is doubtful that these fish were needed, as the bluegill has demonstrated its ability to maintain and even to exceed its place in a balanced population.

7. Of the rough fish using the way, the majority were shad, which are undesirable in Louisiana waters.

8. Tagged fish caught the second time in the trap showed that at least some of the fish (1.8 percent) were returned below the spillway by the overflow.

9. It is the opinion of the authors that a structure like this is not desirable for an impoundment like Lake Chicot. Such a structure provides little harvest for the sport fisherman. Only 22 fish (2.9 percent of the 760 available-size game fish tagged) were returned, and the 760 tagged fish represented 87.9 percent of the total number of available-size game fish utilizing the fishway. Also, such a structure gives access into the lake for large numbers of fish such as shad and undersized sunfish, both of which are nuisances in Louisiana waters because of the tendency to become overabundant.

TRAMMEL NET INCREASES SAMPLING EFFICIENCY OF THE ELECTRIC SHOCKER

For waters where the electric shocker does not provide adequate samples of fish populations, R. Jess Muncy of the Iowa Cooperative Fisheries Research Unit, Iowa State College, recommends the use of a trammel net.

In the Des Moines River, turbid water hid many of the fish stunned below the surface and the deeper holes were difficult to sample adequately. During repeated trials with an electric shocker (0.75-kilovolt-ampere, 110-volt, alternating-current), many fish were seen escaping from the electrical field. Also, large fish captured by hoop nets in the same area were not secured with the electric shocker. When a gill net made of five 25-foot sections (0.75-, 1-, 1.25-, 1.5-, and 2-inch bar-measure mesh) was used to encircle the area sampled, fish were seen striking the net--but few became entangled.

To hold the stunned or escaping fish, a trammel net measuring 200 by 8 feet with 20-inch (stretch) outer mesh and 3.5-inch (stretch) inner mesh was put around a brush pile and hole. Iron stakes were driven into the stream bottom to hold the net in place against the current. When the electric shocker had been used in the hole in the same manner as before, more fish were taken from the trammel net than had been taken after operation of the electric shocker alone.

The combination of gear was particularly successful in taking flathead catfish (Pilodictis olivaris), 21 of which (total length, 13.3 to 38.9 inches) were taken in 7 operations. In several months of hoop-netting in the same area, only 110 flatheads of comparable size were taken.

"In general," writes Mr. Muncy, "the combined gear could not be used in very deep holes because of the difficulty in getting the electrodes far enough into the brush piles to drive out catfish. Also, water currents and floating debris present a problem in maintaining the trammel net, and cleaning the net requires more time than the rest of the operation. However, this sampling method seems quite effective for collecting flathead catfish from sheltering areas at seasons when they are difficult to take by other methods. The two pieces of gear, used together, may also be more effective in collecting other fishes than either the electric shocker or the trammel net used alone."

FURTHER INVESTIGATIONS ON THE USE OF DELRAD AS AN ALGAECIDE IN FISHPONDS

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METHODS AND RATES OF APPLICATION OF DELRAD (dehydroabietylamine acetate) for control of Pithophora and other forms of filamentous algae were described by Lawrence (1954). Since that time, experimental work with Delrad has been continued at the Agricultural Experiment Station of the Alabama Polytechnic Institute. The results of these later tests are discussed here under the following headings: (1) Effectiveness of Delrad as an algaecide, (2) effects of Delrad on fish production in ponds, and (3) effectiveness of Delrad-Roccal mixture as an algaecide.

Effectiveness of Delrad as an Algaecide

Delrad has proved to be an effective control agent for certain monofilament forms of algae, including Spirogyra and Oedogonium. At the present time its value as a practical control agent for Pithophora, Rhizocolonium, and Hydrodictyon is doubtful. Though in most cases this chemical will drastically reduce growths of these algae in ponds, its effects are of short duration (from 1 to 3 weeks) and its cost is excessive (approximately $5 per acre per application). However, the effects of applications of this chemical on fish production in ponds are much less detrimental than are those of sodium arsenite (Lawrence, in press); thus it still has use as a fishery-management tool.

The active ingredient of Delrad is dehydroabietylamine acetate, and it is available as a 50-percent liquid or a 70-percent paste. The minimum lethal dose of dehydroabietylamine acetate for bluegill (Lepomis macrochirus) and largemouth bass (Micropterus salmoides) fingerlings is approximately 0.65 p.p.m. The concentration normally used in pond waters to control algae is from 0.25 to 0.3 p.p.m. dehydroabietylamine acetate. These concentrations have not killed fish when applied by the float method. Under certain conditions, however, when applied by the drag or spray method, Delrad will kill small fish. These kills are usually obtained when the small fish are congregated in the shallow water at the pond edge. When the Delrad is applied a few feet from the edge, the small fish are trapped in a lethal concentration of the chemical. This can be avoided, generally, by starting the application at the bank and working out into the pond. Such a procedure tends to drive the small fish into deeper, safer water in front of the Delrad. Any kill of fish from this chemical will usually occur within a few minutes to 2 hours after the Delrad is applied. Apparently its effects as an algaecide are also limited to a very few hours after application.

The rapid dissipation of algaecidal properties of Delrad has resulted in unsatisfactory control of Pithophora in fishponds. It appears that if the Delrad is applied in the surface waters, it will kill Pithophora on the pond surface, but it does not reach the algae on the pond bottom in 4 to 6 feet of water. Often, if the Delrad is applied on the pond bottom in 4 to 6 feet of water, the chemical does not reach the algae on the surface, especially

at the pond edge. Apparently the logical solution would be to apply a higher concentration of Delrad so that algae in both places could be killed. However, when this was done, the chemical did not give a complete kill of the algae and did give an excessive kill of small fish in the ponds.

A concentration of more than 30 p. p. m. of dehydroabietylamine acetate was maintained in a pond for 8 weeks during the summer of 1954. This pond was drained during the winter of 1954-55 and subsequently refilled with fresh water. During the summers of 1955 and 1956, a heavy growth of Pithophora developed in this pond. Thus, there is no indication of any residual action of Delrad on this alga. It would also appear that this chemical had no toxic effects on the spores of Pithophora.

Effects of Delrad on Fish Production in Ponds

Tests conducted in six 0. 25-acre ponds during the spring of 1955 indicated that as many as 3 applications of 0. 3 p. p. m. dehydroabietylamine acetate had no harmful effects on spawning activities, hatching of eggs, or survival of fry and small fingerlings of largemouth bass in these ponds. In four of these ponds great care was used in applying the Delrad as evenly as possible over the entire pond; in the other two ponds, the Delrad was applied from floats. Plankton samples were taken from these ponds throughout the treatment period. These samples showed no discernible differences in the types or quantities of phytoplankton or zooplankton present in the untreated and treated ponds. From laboratory tests it appears that microcrustaceans suffer approximately a 50-percent mortality when the concentration of dehydroabietylamine acetate reaches 0. 5 p. p. m. in the pond water.

Eight 0. 25-acre ponds were used to determine the effects of different numbers of treatments with Delrad, applied by different methods, on bottom organisms and on bluegill production. In two ponds only two treatments with 0. 25 p. p. m. dehydroabietylamine acetate were applied by floats. In the remaining four ponds, four applications of 0. 25 p. p. m. were made. In two of the latter ponds the Delrad was applied in floats, whereas in the other two ponds it was applied by dragging on the pond bottom.

Samples of the bottom organisms were taken at 2-week intervals throughout the test period. Though considerable variation in the production of bottom organisms was encountered, it was not demonstrated that there were any real production differences in the treated and untreated ponds. When the ponds were drained approximately 2 months after the last treatment with Delrad, there was no difference in bluegill production in the treated and untreated ponds.

From these tests it was concluded that no serious effects on fish production would be expected for ponds that received as many as four applications of 0. 25 p. p. m. dehydroabietylamine acetate. Whether a greater number of applications of Delrad to a pond in one season would reduce fish production is unknown. However, when it is considered that a heavy infestation of Pithophora will reduce fish production from 50 to 80 percent, some slight reduction due to treatment with Delrad may be tolerated.

Effectiveness of Delrad-Roccal Mixture as an Algaecide

The effectiveness of Delrad as an algaecide was increased by combining that chemical with Roccal (benzalkonium chloride). The mixture that has given the most satisfactory results in the control of Pithophora has consisted of equal parts of Delrad 50-S and Roccal (10 percent). The rate of application has been approximately 0. 25 p. p. m. dehydroabietylamine acetate and 0. 05 p. p. m. benzalkonium chloride concentration for the entire volume of water in the pond. This mixture has been applied as a spray solution to the algae on the surface and as an underwater spray over masses of algae growing on the pond bottom, with equally effective results.

The minimum lethal dose of benzalkonium chloride for bluegill is 1. 9 p. p. m.

The toxicity to bottom organisms and microcrustaceans has not been determined. However, tests in ponds during 1956 did not indicate any excessive reduction in either type of food in ponds where this mixture had been used for control of algae.

Unfortunately, this mixture will not give a complete kill of Pithophora in a pond. However, the control obtained from a single application will last from 2 to 4 weeks in heavily infested ponds and longer in lightly infested ponds. The primary use for this spray at present would be in hatchery ponds where a rapid kill of the algae is desired at draining-time.

Summary

Concentrations of 0.25 to 0.3 p.p.m. dehydroabietylamine acetate (Delrad) killed large amounts of Pithophora in ponds, but the effects were of short duration (1 to 3 weeks).

As many as three applications of Delrad at the concentration of 0.3 p.p.m. dehydroabietylamine acetate in bass brood ponds did not affect spawning of bass, hatching of eggs, or survival of fry and small fingerlings. As many as four applications of Delrad at a concentration of 0.3 p.p.m. dehydroabietylamine acetate did not affect reproduction or production of bluegill in experimental ponds.

The addition of an equal part of Roccal (10 percent) to Delrad 50-S produced a better kill of Pithophora in ponds, and the effects were usually of longer duration (2 to 4 weeks).

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MORE DRUGS TESTED FOR CONTROL OF KIDNEY DISEASE

Further studies of the effectiveness of chemotherapeutic agents in the control of kidney disease (see PROGRESSIVE FISH-CULTURIST 20: 26) have been reported by Dr. K. E. Wolf from the Eastern Fish Disease Laboratory of the Bureau of Sport Fisheries and Wildlife, Kearneysville, West Virginia.

Selected on the basis of in vitro effectiveness, the 6 drugs listed in the accompanying table were fed for 21 days to brook trout that had been infected experimentally with kidney disease. The mortalities that are shown occurred within a period of 3 months after the treatments with these drugs had been stopped.

"Only fish that had received erythromycin," writes Dr. Wolf, "were saved for further observation."

MORTALITY AMONG BROOK TROUT ABOUT THREE MONTHS AFTER CESSATION OF VARIOUS TREATMENTS FOR KIDNEY DISEASE

Treatment	Dosage (mg./kg./day)	Cumulative percentage mortality
Phenoxyethanol.....	200	78
MK-51 (2-Acetylamino-5-Nitrothiazole).....	40	65
Sodium Penicillin G.....	75	59
Kynex (Sulfamethoxypyridazine).....	200	39
Erythromycin.....	100	11
Gantrisin (Sulfisoxazole)	200	74
Inoculated controls.....	.....	83

APPARATUS FOR TAKING NEAR-BOTTOM WATER SAMPLES IN LAKES

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Department of Biological Sciences, University of Idaho
Moscow, Idaho

FACED WITH THE PROBLEM of taking sizable water samples at a distance of only 1 to 10 centimeters above the substratum in lakes, this writer has constructed a simple apparatus which has proved to be reasonably efficient. The sampler described here incorporates a number of innovations, is inexpensive to build, and may be of interest to others who are working on the benthos. With an over-all height of 57 centimeters and an empty weight of about 20 pounds, the sampler can be used under almost all conditions of depth and substratum type common to small to medium-sized lakes.

Basically, the operating principle of hydrostatic pressure gradient employed in the sampler was first utilized by Hale (Welch 1948) in the United States. Like Hale's device, the present sampler incorporates a large reservoir bottle and a smaller sample bottle (figure 1). The top of the outlet tube in the reservoir bottle is 53 centimeters above the inlet-tube opening in the sample bottle. Thus, according to the equation $P = hd$, a pressure difference of 53 grams/centimeters^2 obtains between the two openings. For any depth, this figure is reasonably constant and is merely a function of the vertical distance between the tube openings.

Both bottles rest on the base of the sampler, and it in turn is allowed to rest on the lake bottom. Further, the inlet-tube opening is placed within 1 centimeter of a V-shaped horizontal projection of the flat sampler base. Exhaustive tests in an

FIGURE 1.--The finished sampler. Note rope bottle retainers and appearance of air-release mechanism in closed position.

(Illustrations courtesy of the author)

Contribution No. 30, Limnology Laboratory, Department of Biology, University of Colorado.

aquarium have demonstrated that the inlet tube so arranged will sample a horizontal layer of water within 5 centimeters of the interface.

When the device is submerged, the outlet tube is stoppered to prevent water from entering the intake tube of the sample bottle until a sample is to be collected. The stoppering mechanism is released by dropping a brass messenger down the attached rope.

Materials required to construct a sampler similar to the original model, at a total cost of less than $5, are as follows:

Galvanized sheet tin	1 sq. yd., 16 gauge
Window sash weight	40.5 cm. long, 5 cm. diameter
Bolts, galvanized	Sixteen 0.5 in., one 3.5 in., 4.5 mm. diameter
Glass tubing	7 and 5 mm. diameter
Rubber tubing	6 and 4 mm. inner diameter
Rubber stoppers	One 2-hole, No. 6; one 2-hole, No. 2 or 3; one 1-hole, No. 3
Reservoir	Gallon bottle
Sample bottle	300-ml. standard taper, or ordinary 250- to 300-ml. glass-stoppered reagent type

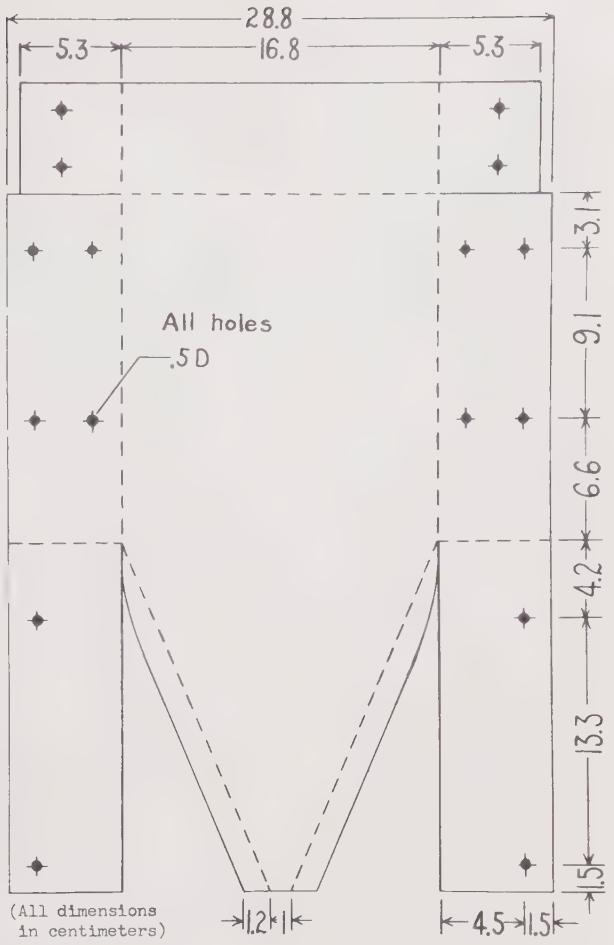

FIGURE 2. -- Flat template of base of water sampler. Solid lines indicate cutting plane; dashed lines, folding plane.

Lay out the base measurements (figure 2) on the sheet tin and cut with tin shears. Proceed in like manner with all other parts, using measurements in figure 3. Shape the base; then assemble vertical supports as in A and B, figure 3. Edges of vertical, horizontal, and oblique supports should be bent to nearly a right angle as a strengthening aid, using dimensions in figure 3 (A). Two rubber tubing spacers are required to center the metal fulcrum of the stopper-arm assembly (C of figure 3) in proper operating position. Here, also, the outermost end of the rubber tube which fits over and stoppers the reservoir outlet tube must be filled with a waterproof cement to ensure an airtight closure. A window sash weight should be sawed in half and the two pieces clamped to the sides of the base as in D of figure 3. The tubing assembly is depicted in figure 4. Glass tubing of 5-millimeter diameter should be used for the inlet tube. When inserted into the sample bottle, the lowermost horizontal component should lie within 1 centimeter of the base of the sampler, and the opening should fit into the apex of the V-shaped base projection. Glass tubing of 7-millimeter diameter should be used to make that portion of the tubing assembly which is inserted into the reservoir bottle. These two components of the tubing assembly should be connected with a 26-millimeter length of 4-millimeter (inner diameter) rubber tubing. Of course, all measurements in figure 4 are approximate; precise figures

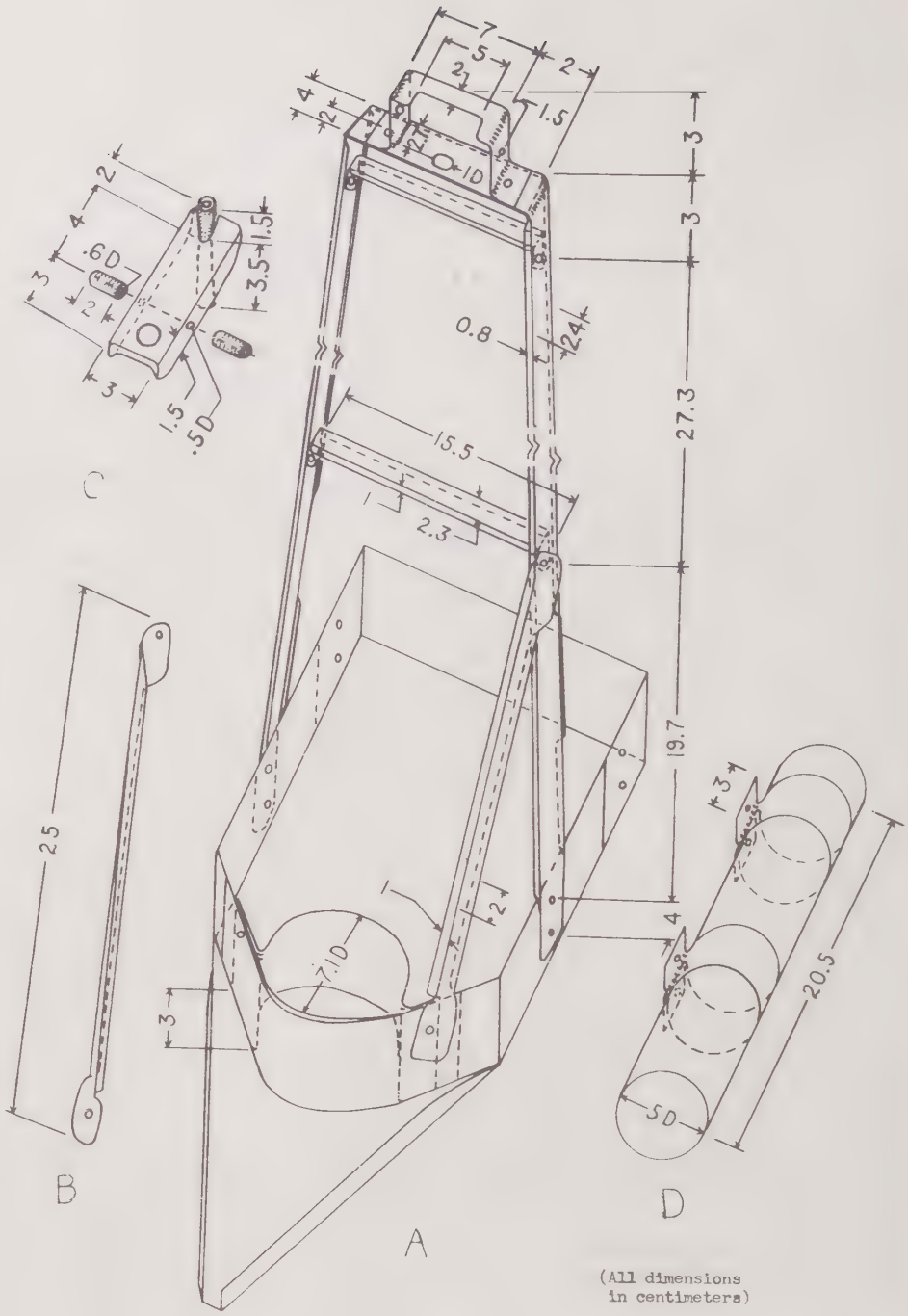

FIGURE 3. -- Working drawing of framework of the water sampler. A, base and vertical support assembly; B, expanded view of left oblique support; C, expanded view of stopper arm assembly; D, weight and clamp assembly (two are needed).

depend on the particular volumes of sample and reservoir bottles. Further, the outlet-tube opening should be fire-polished to a small diameter, for reasons stated below.

The sample bottle should be tightly fitted into its holder in the base of the sampler, and the reservoir bottle securely fastened in place with a length of rope as in figure 1. When the sampler is fully assembled, the framework should be painted. Aluminum paint works well for this purpose. Proper balance may be obtained by moving the weights forward or backward while the sampler is freely suspended. Once these weight positions have been determined, they may be permanently soldered to the clamps.

Wire-core plastic rope is recommended because it is light and inelastic yet provides an adequate safety margin of strength. Depth intervals may be marked on the plastic with a waterproof stain such as Sudan IV in isophorone. Intervals marked with this stain remained clearly legible after a year of heavy use.

Before sampling is started, inspection of all rope and fittings is necessary to ensure proper alignment of the various units within the framework. Then the

closing device should be set and the apparatus lowered to the bottom slowly but at a uniform rate. The device should be allowed to remain on the bottom, particularly on soft flocculent sediments, for a few minutes before releasing the messenger. Return of reasonably uniform conditions at the interface is thus assured just prior to sampling.

Depending on the inner diameter of the outlet tube, a period of 10 to 12 minutes is required to fill the reservoir bottle. When all flow of air from the sampler has stopped (as indicated by cessation of bubbles), it may be raised slowly to immediately below the surface, and the outlet restoppered to prevent a reversal of water flow through the system as the sampler breaks surface. Water remaining in the inlet tube will flow into the sample bottle as the tubing is removed. However, little or no error is introduced, as this water is presumed to be from within the 5-centimeter bottom layer of water. The effect of overlying water pressures on the small diameter of the outlet tube is not great enough to induce a reversal of flow during recovery, even from deep lakes. Admittedly, about 15 minutes per sample is required, but the writer believes that the increased accuracy obtained more than compensates for any loss of time as compared to other common sampling methods.

For the most part, the writer has had little difficulty in taking adequate samples. At times, however, the inlet tube becomes clogged with Aphanizomenon when growth of this blue-green alga is dense. Particles of mud and sand are mostly deposited in the reservoir bottle, leaving the sample bottle free of settleable material. Nevertheless, one should determine the effect of any introduced organic or inorganic matter on samples taken for dissolved oxygen analysis (Ellis 1948) and correct by titration modifications if necessary. The small volumes of mud and sand present, if any, usually do not alter the volume of water sampled; but if appreciable quantities of debris remain in the sample bottle, they must be taken into account. One may either determine the resultant volume loss or construct and substitute an

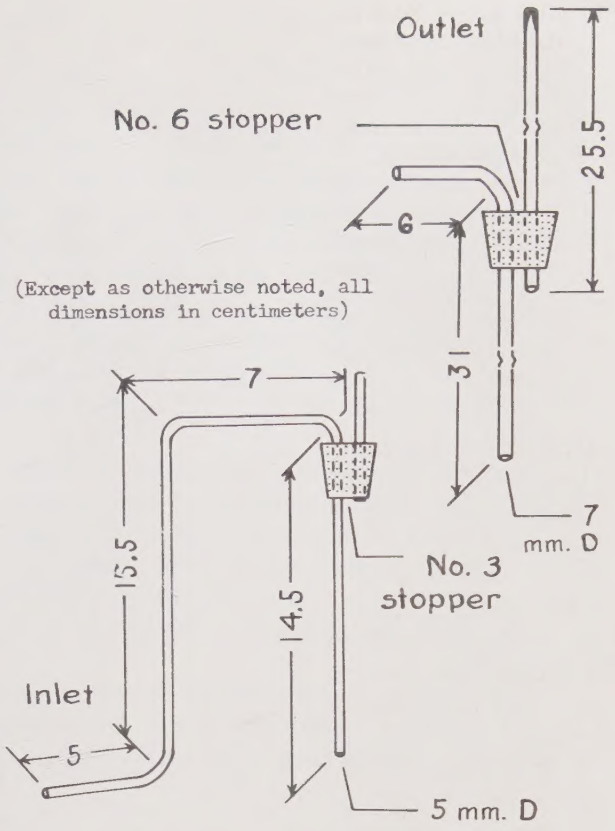

FIGURE 4.--Side view of tubing assembly for water sampler. For clarity, all rubber parts are stippled and the rubber connecting tube is omitted.

inlet tube with the lowermost horizontal component raised a few centimeters above the V-shaped sampler base. Then, if the sampler does penetrate the soft bottom a few centimeters, the inlet opening will still lie within the 5-centimeter layer of water just above the bottom and a clean sample can be collected. The writer prefers the latter technique for quantitative accuracy, but it is recommended only if the substratum will not firmly support the weight of the sampler.

The sampler will not function properly if the inner diameter of the outlet tube is larger than the corresponding inlet diameter. Indeed, the former measurement should be at least 0.5 millimeter smaller, so as to assure an uninterrupted flow of air through the system, as evidenced by a continuous stream of air bubbles during operation. The magnitude of the force of

water acting on sampler air is in direct proportion to the areas of contact. As these areas are initially represented by the diameters of the inlet and outlet tubes, the foregoing relation must obtain. Otherwise, at times water will tend to flow inward through the outlet, and "blurps" of air will be emitted. Proper flow will then be inhibited until the water pressure on the system is markedly reduced, i.e., when the reservoir bottle is more than half full. Complete change of water within the sample bottle is doubtful under such conditions.

To prevent bubble formation in stoppering, the rubber stopper of the sample bottle should not project into the neck more than 7 millimeters and water remaining in the inlet tube should be allowed to flow into the sample bottle as it is removed.

Undoubtedly, future construction materials will be of stainless steel for added durability. Moreover, a lead plate of appropriate size placed in the base of the sampler should be better than attached weights. However, the total size and weight of a sampler constructed from this plan should not exceed those of the original model--and may even be reduced to a considerable degree as personal requirements dictate. It is recommended that the uppermost brace in the vertical support be fitted with a length of rubber hose on the lower side to facilitate carrying.

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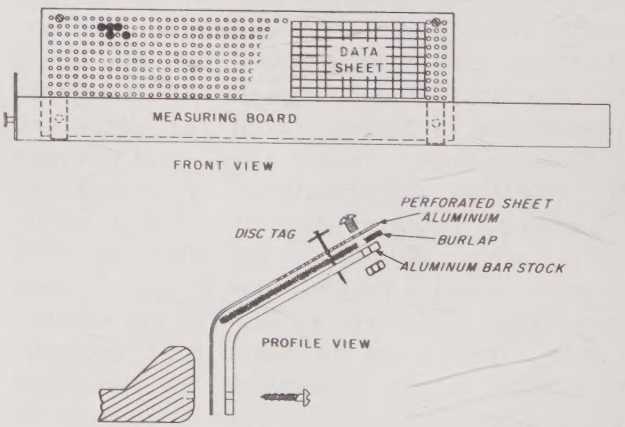
A TAG HOLDER FOR USE IN THE FIELD

To help to keep tags in order and in a position convenient to the tagger--especially if the tagging is a one-man operation--A. C. Jensen of the North Atlantic Fishery Investigations, Bureau of Commercial Fisheries, Woods Hole, Massachusetts, recommends a holder designed specifically for Petersen disc tags and similar tags fastened with pins or wires.

Two thicknesses of perforated sheet aluminum, riveted together with aluminum rivets for greater rigidity, are bolted to a frame of aluminum bar stock (1 by 0.25 inch) with aluminum nuts and bolts. A double thickness of burlap is "sewn" with stainless steel wire to the underside of the perforated aluminum. When moistened, the burlap securely holds the tag pins or wires that are thrust through the perforations in the aluminum. The tag holder is fastened to the measuring board with brass screws.

A sheet of opaque white plastic, matte side up, can be attached to the right side of the holder. India-ink guide lines on the plastic enable the tagger to write in tag numbers and fish lengths with a pencil. Such notes are easily erased after transfer of the data to permanent tagging records.



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